Appendix 3-3: GDE/NDVI Assessment

1 Sierra Valley Groundwater Dependent Ecosystems SMC Assessment

To assess whether Sustainable Management Criteria (SMC) are likely to impact groundwater dependent ecosystems (GDEs), we assessed the linkage between groundwater elevation and vegetation health and considered the species composition of GDEs near Representative Monitoring Points (RMPs). SMC may negatively affect GDEs if they lower groundwater elevation below the rooting depth of GDE vegetation. At each RMP, we assessed changes in NDVI and groundwater depth through time and relationships between NDVI and groundwater depth. The results are presented in this appendix.

1.1 Methods

For each RMP with defined SMC, we compiled the areal extent and dominant vegetation community of mapped GDE polygons that fall within a 1-mile radius. GDE polygons that lie partially within this area are also included, and a single GDE polygon may be counted in analyses for multiple wells. We also tracked Normalized Difference Vegetation Index (NDVI) trends through time and the relationship between NDVI and groundwater depth at these wells, noting any changes that occurred at groundwater elevations near the MO or MT. NDVI, which estimates vegetation greenness, was generated from surface reflectance corrected multispectral Landsat imagery from July 1 to September 30 of each year, which represents the summer period when GDE species are most likely to use groundwater (Klausmeyer et al. 2019). Vegetation polygons with higher NDVI values indicate increased density of chlorophyll and photosynthetic capacity in the canopy, an indicator of vigorous, growing vegetation. NDVI is a commonly used proxy for vegetation health in analyses of temporal trends in health of groundwater-dependent vegetation and is essentially a measure of the greenness of remotely sensed images (Rouse et al. 1974 and Jiang et al. 2006 as cited in Klausmeyer et al. 2019).

This analysis was conducted for the 30 RMP where any GDEs occur within a one-mile radius, including four shallow wells (total completion depth < 100 ft). Changes to the areal extent of dominant vegetation communities through time would require repeated mapping efforts, which are not available. In addition, the available vegetation maps lack species information so we were therefore unable to assess potential effects of MTs and MOs using rooting depth. Instead, we relied on linkages between summer NDVI values and summer groundwater depth.

The depth to groundwater was the water depth measured closest in time to August 1 (the median summer NDVI date). Only measurements within 13 weeks of August 1 were used. Linear regression was used to test whether NDVI changed in response to changes in groundwater elevation (or depth). Where the regression was statistically significant (p-value<0.05), it was assumed that changes to water depth were at least partially responsible for changes in NDVI. Changes to NDVI are not solely dependent on groundwater levels and could also result from more abundant surface water, higher soil moisture content, and other climatic factors (e.g., summer rainfall or temperatures).

1.2 Results

Table Appendix 3-3-1 and Figure Appendix 3-3-1 to Appendix 3-3-30 show the results of this analysis for each RMP well where GDEs occur within a 1-mile radius. The first panel of each

figure shows time series of NDVI and groundwater elevation. The second panel shows summer NDVI versus depth to groundwater, where available within 13 weeks of August 1.

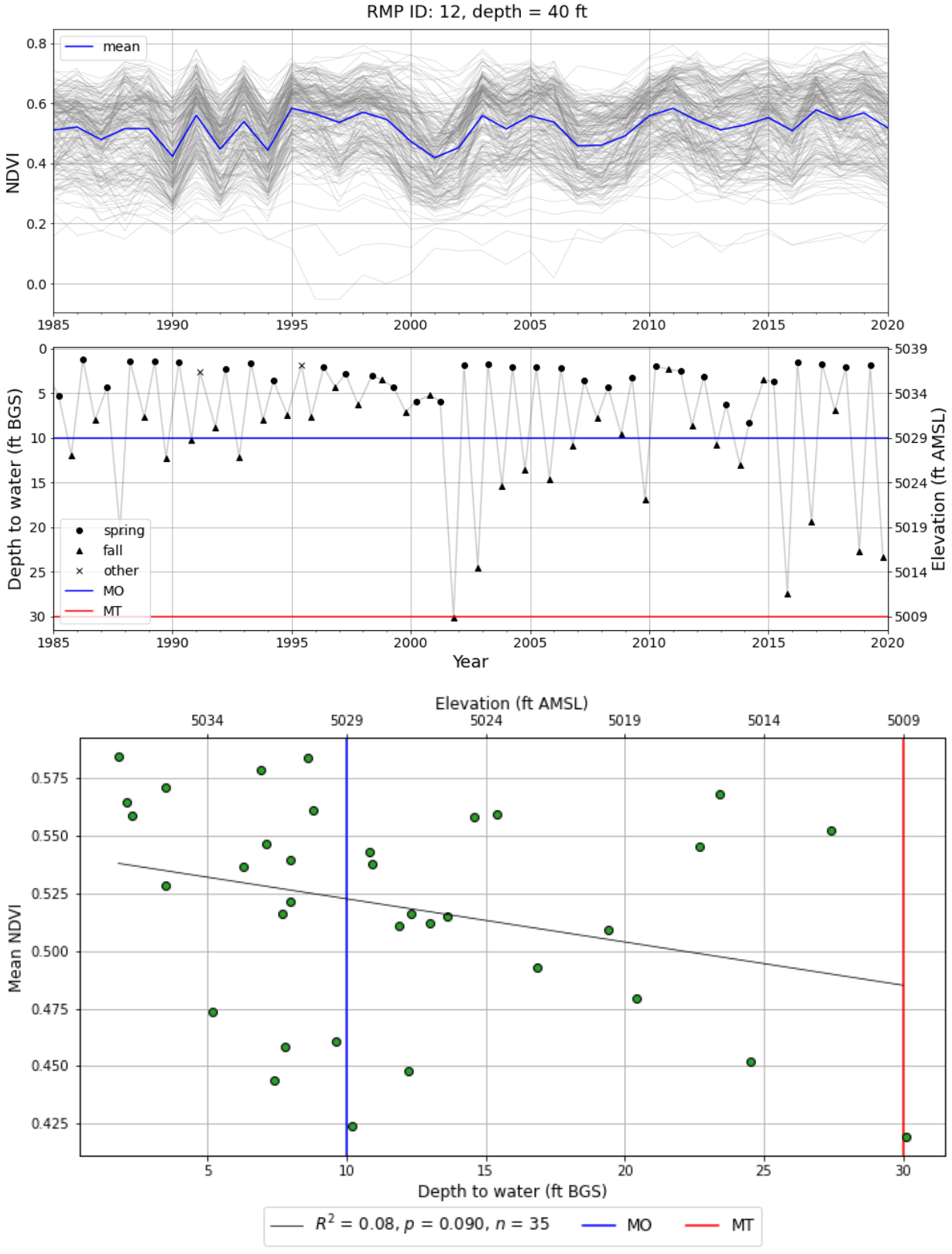
13 of the RMPs with GDEs within a 1-mile radius have a statistically significant (p-value < 0.05) relationship between summer NDVI and groundwater elevation. Based on historical NDVI and groundwater levels, MOs and MTs were adjusted to conservatively limit impacts at RMP IDs 93, 209, 291, and 300.

Table Appendix 3-3-1: Summary statistics for RMPs and linear regression.

RMP ID	Site Code	Screened Interval (ft BGS)	Total Completion Depth (ft BGS)	MO (ft AMSL)	MT (ft AMSL)	GDE Area Within One Mile (Acres)	Number of Groundwater Elevation Measurements	NDVI vs. Depth to Groundwater Linear Regression p-Value
12	395808N1203851W001	Unknown	40	5,029	5,009	215	35	0.09
31	396391N1203667W001	Unknown	60	4,921	4,913	178	29	0.003
56	396814N1202407W001	35 – 325	360	4,893	4,865	36	30	0.02
67	396934N1202234W001	Unknown	200	4,916	4,899	45	31	0.327
70	396864N1202299W001	161 – 245	400	4,902	4,871	54	23	0.204
78	396599N1202229W001	Unknown	400	5,072	5,061	64	6	0.103
93	397667N1203238W001	Unknown	943	4,878	4,873	840	36	0.028
130	397081N1202449W001	150 – 420	426	4,873	4,840	46	30	0.149
131	397927N1201294W001	Unknown	130	5,052	5,038	104	32	0.005
132	397945N1201920W001	Unknown	251	4,908	4,891	270	30	0.247
136	397831N1202245W001	589 – 816	820	4,801	4,746	<1	35	0.247
148	397372N1202128W001	70 - 190	205	4,934	4,929	64	31	0.618
161	398020N1203815W001	Unknown	18	4,872	4,864	537	28	0.008
176	398094N1202932W001	Unknown	137	4,872	4,863	<1	31	0.378
185	398107N1201653W001	Unknown	300	4,958	4,955	179	35	0
187	398165N1201934W001	Unknown	257	4,921	4,905	275	30	0.895
190	398098N1202211W001	477 – 180	820	4,812	4,760	1	31	0.263
194	398059N1201862W001	230 – 290	297	4,921	4,904	311	28	0.771
206	398024N1201371W001	Unknown	230	5,002	4,987	118	33	0.012
209	397951N1201418W001	Unknown	50	5,003	4,994	159	35	0
289	395951N1203910W003	420 – 450	675	4,954	4,950	399	19	0.115
291	395951N1203910W001	85 – 100	675	4,946	4,943	399	19	0.042

RMP ID	Site Code	Screened Interval (ft BGS)	Total Completion Depth (ft BGS)	MO (ft AMSL)	MT (ft AMSL)	GDE Area Within One Mile (Acres)	Number of Groundwater Elevation Measurements	NDVI vs. Depth to Groundwater Linear Regression p-Value
292	396444N1204137W003	340 – 455	440	4,912	4,892	543	13	0.313
294	396444N1204137W001	90 – 100	440	4,912	4,871	543	18	0.115
296	396722N1204095W002	530 – 550	720	4,883	4,875	97	19	0.004
297	396722N1204095W001	210 – 240	720	4,897	4,889	97	19	0.022
298	397956N1201417W001	290 – 320	360	5,007	4,998	159	17	0
300	397956N1201417W003	75 – 90	360	5,001	4,996	159	17	0.001
301	398170N1203478W001	310 – 340	490	4,856	4,836	50	17	0.529
302	398170N1203478W002	115 - 130	490	4,865	4,835	50	17	0.718

Figure Appendix 3-3-1. RMP 12



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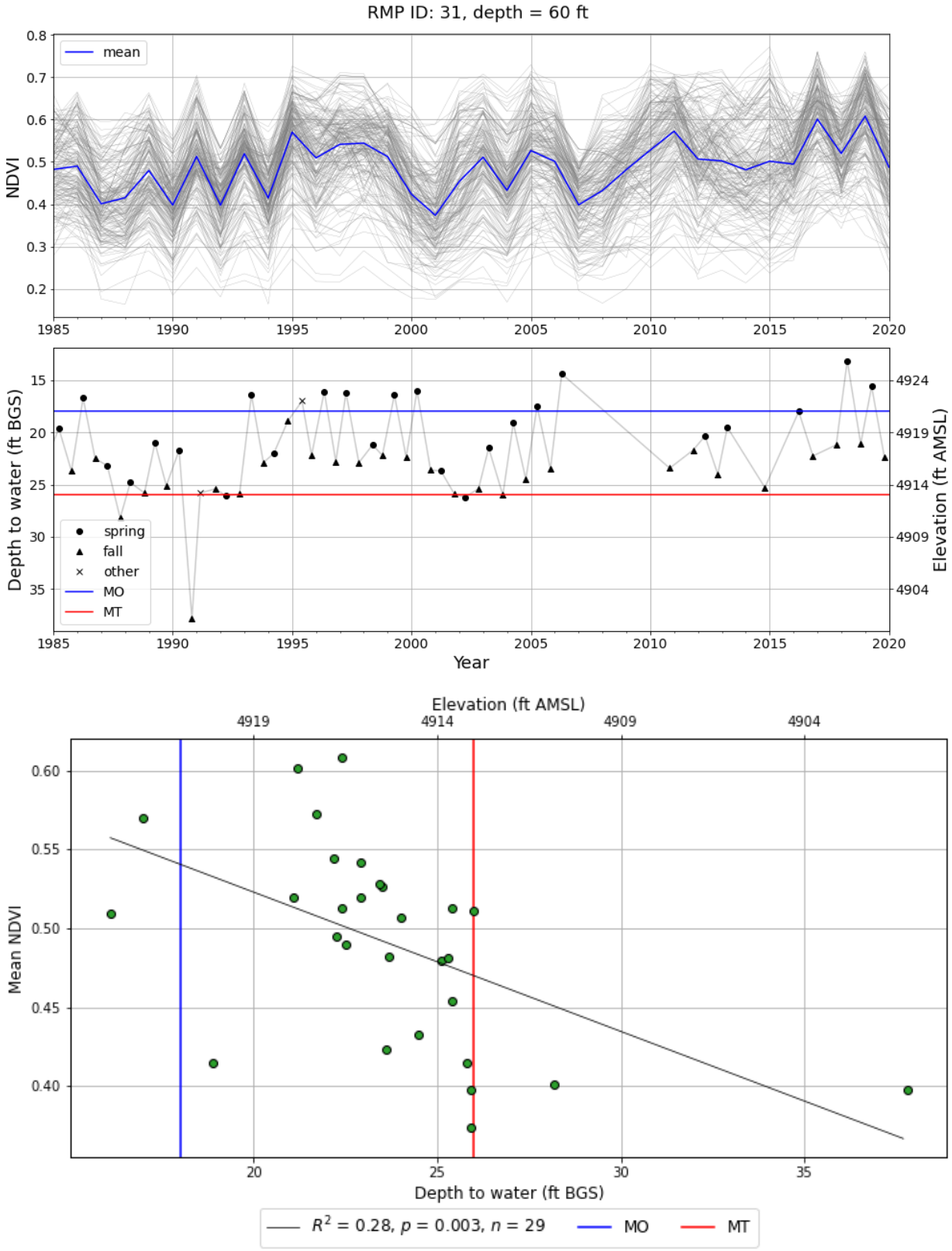

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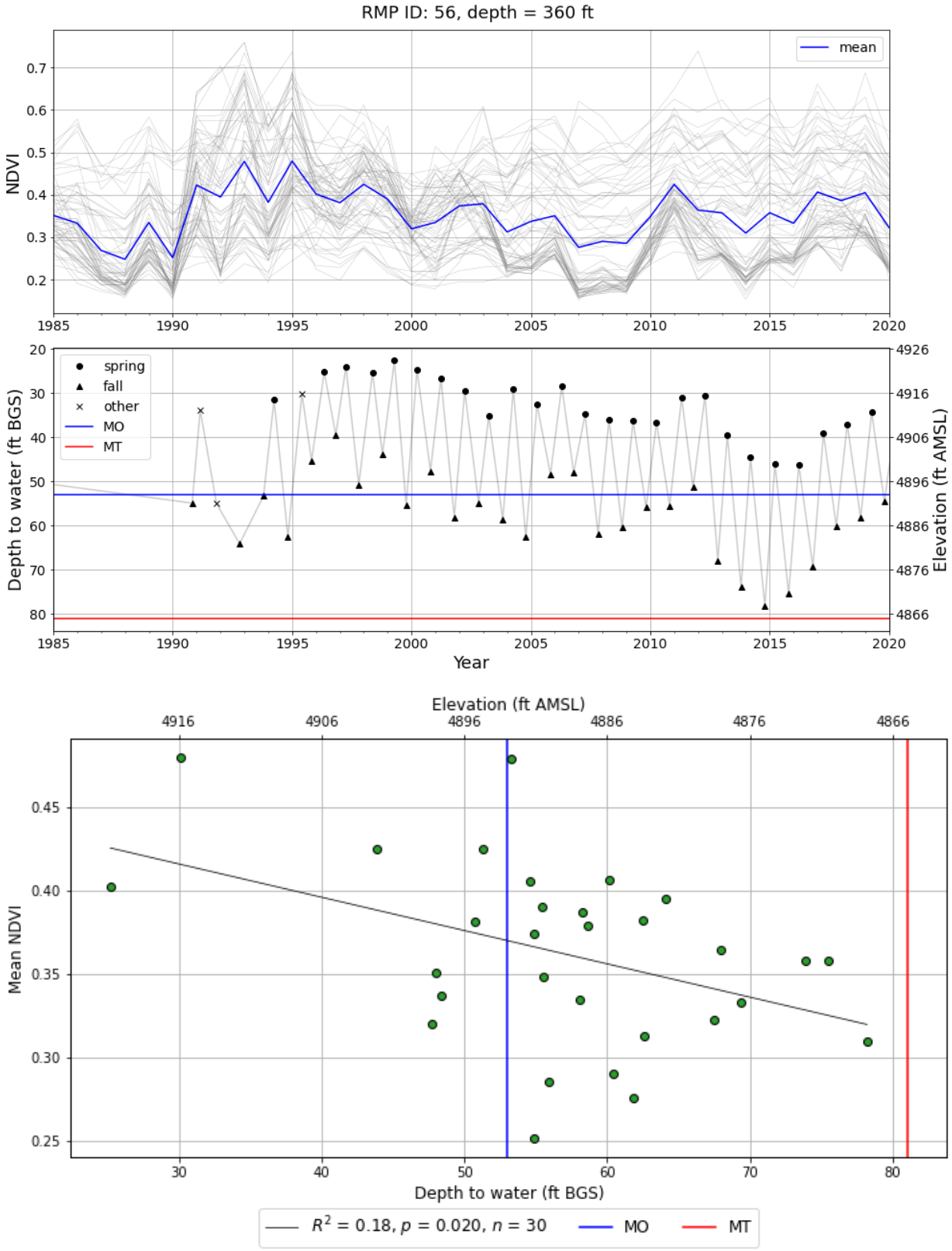

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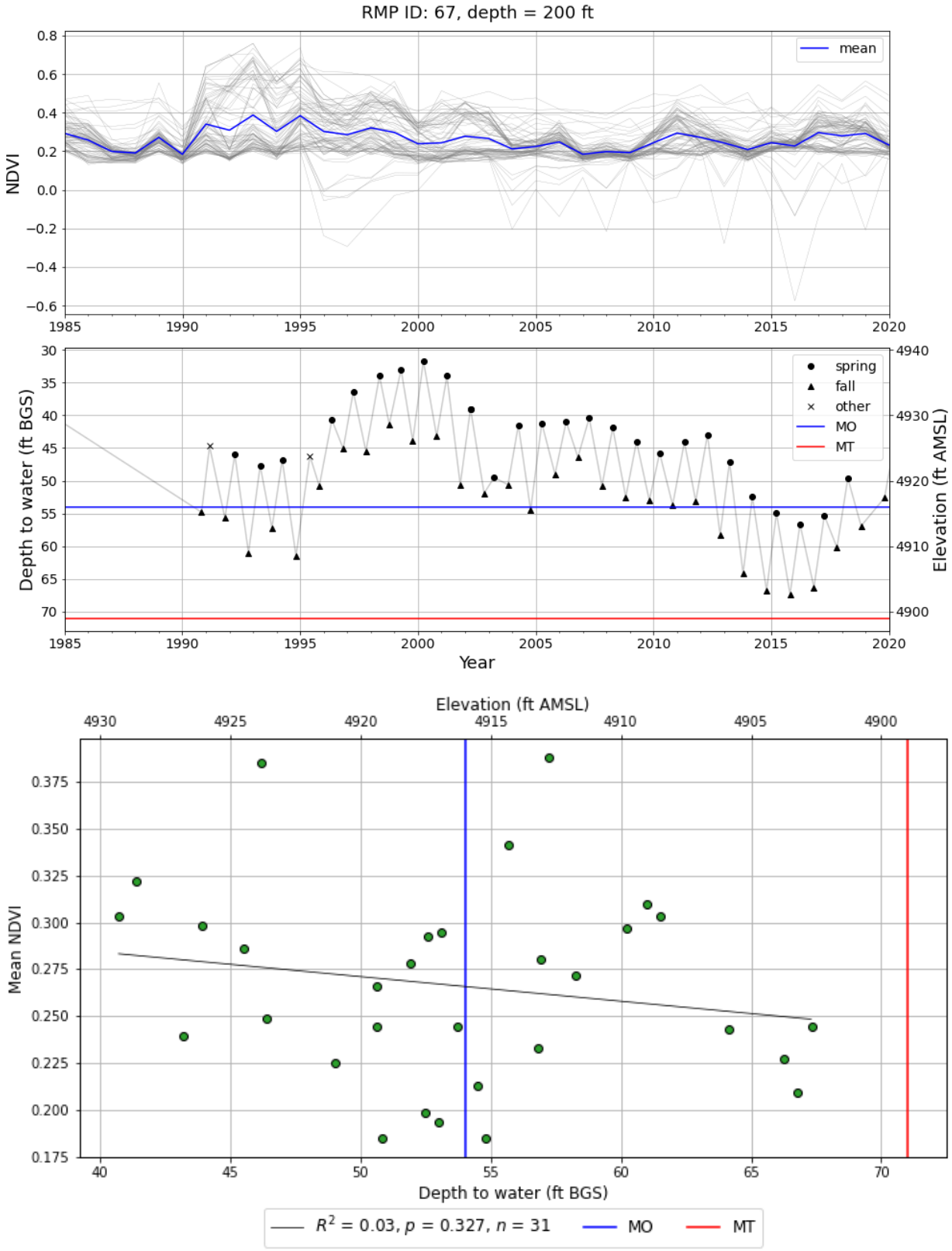

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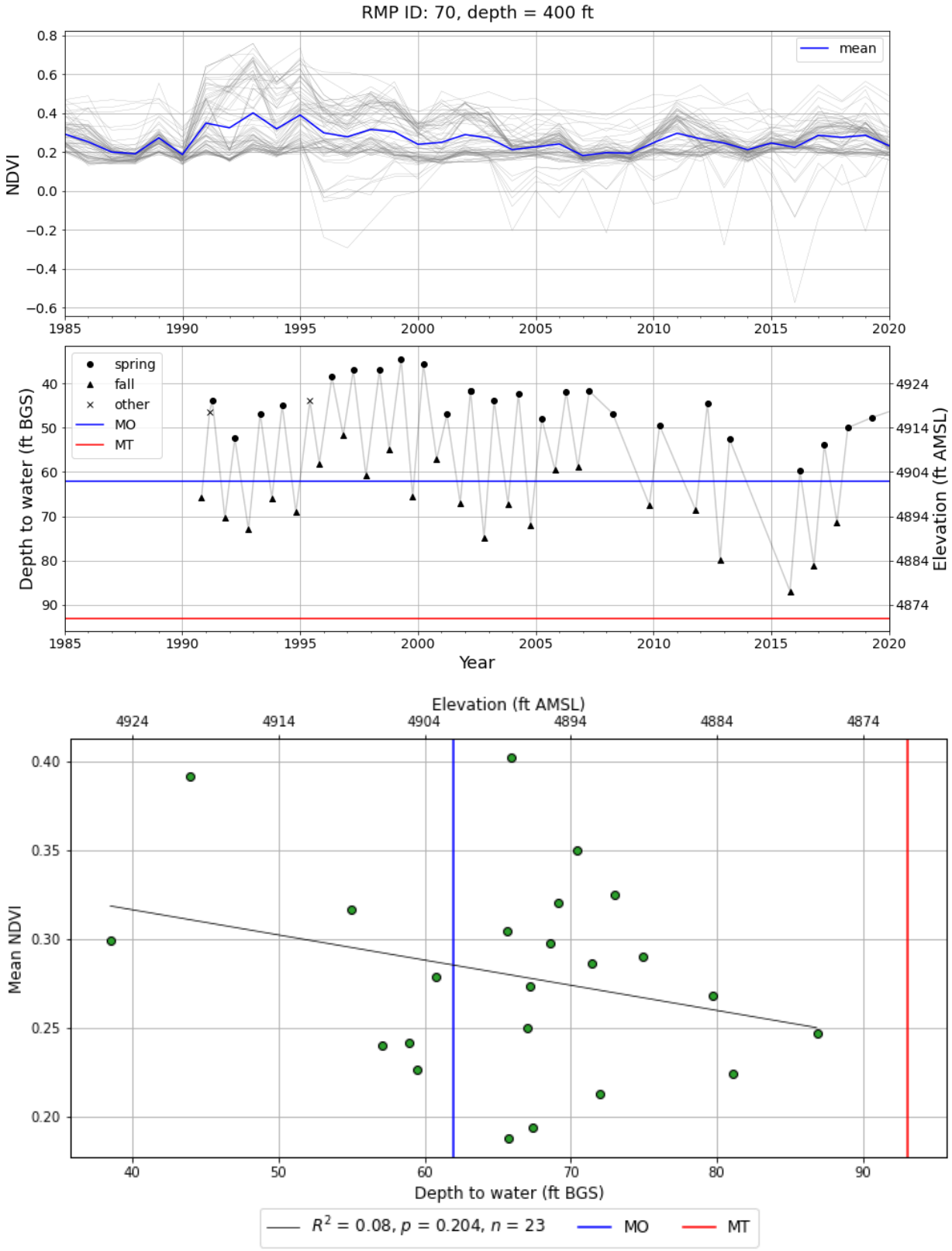

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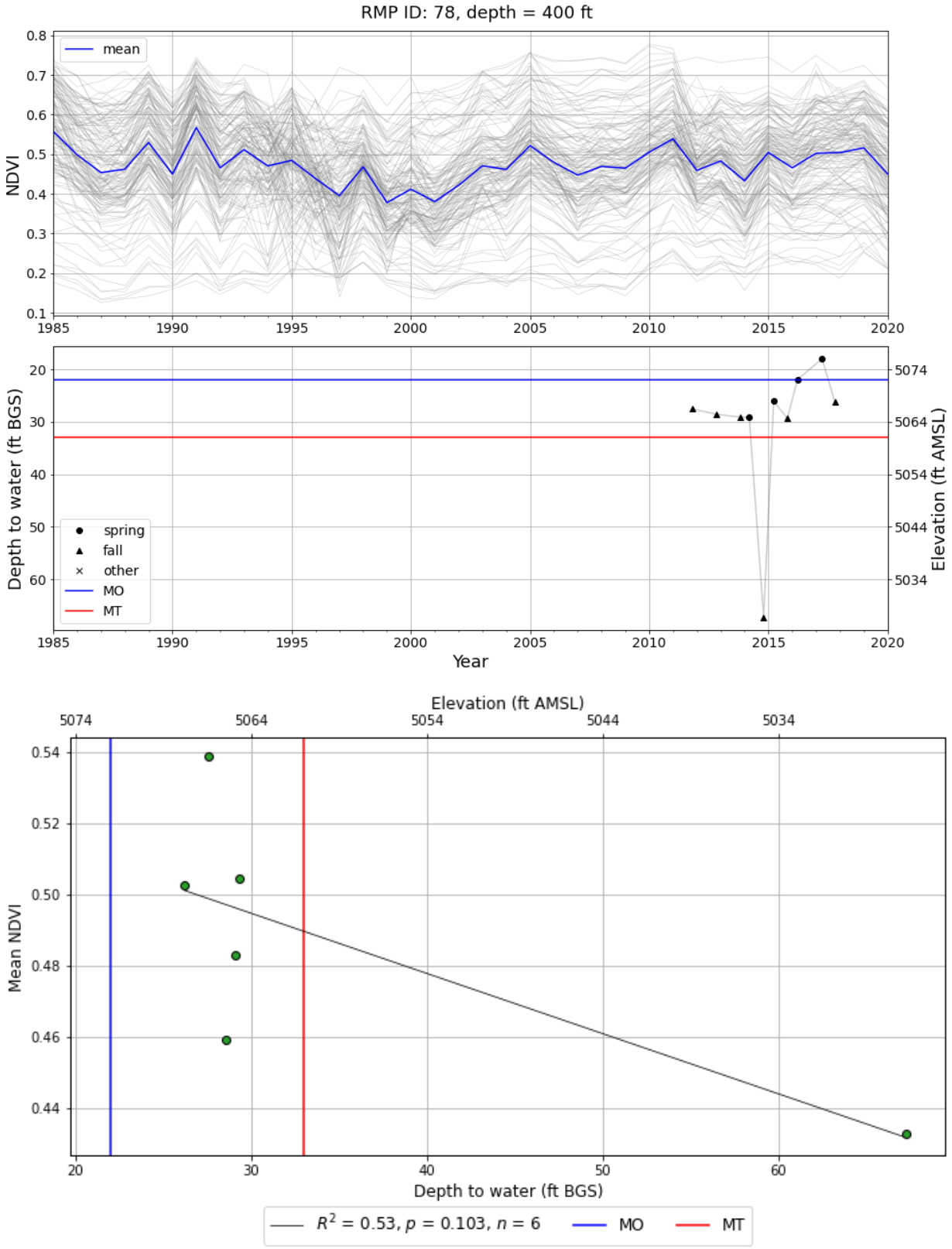

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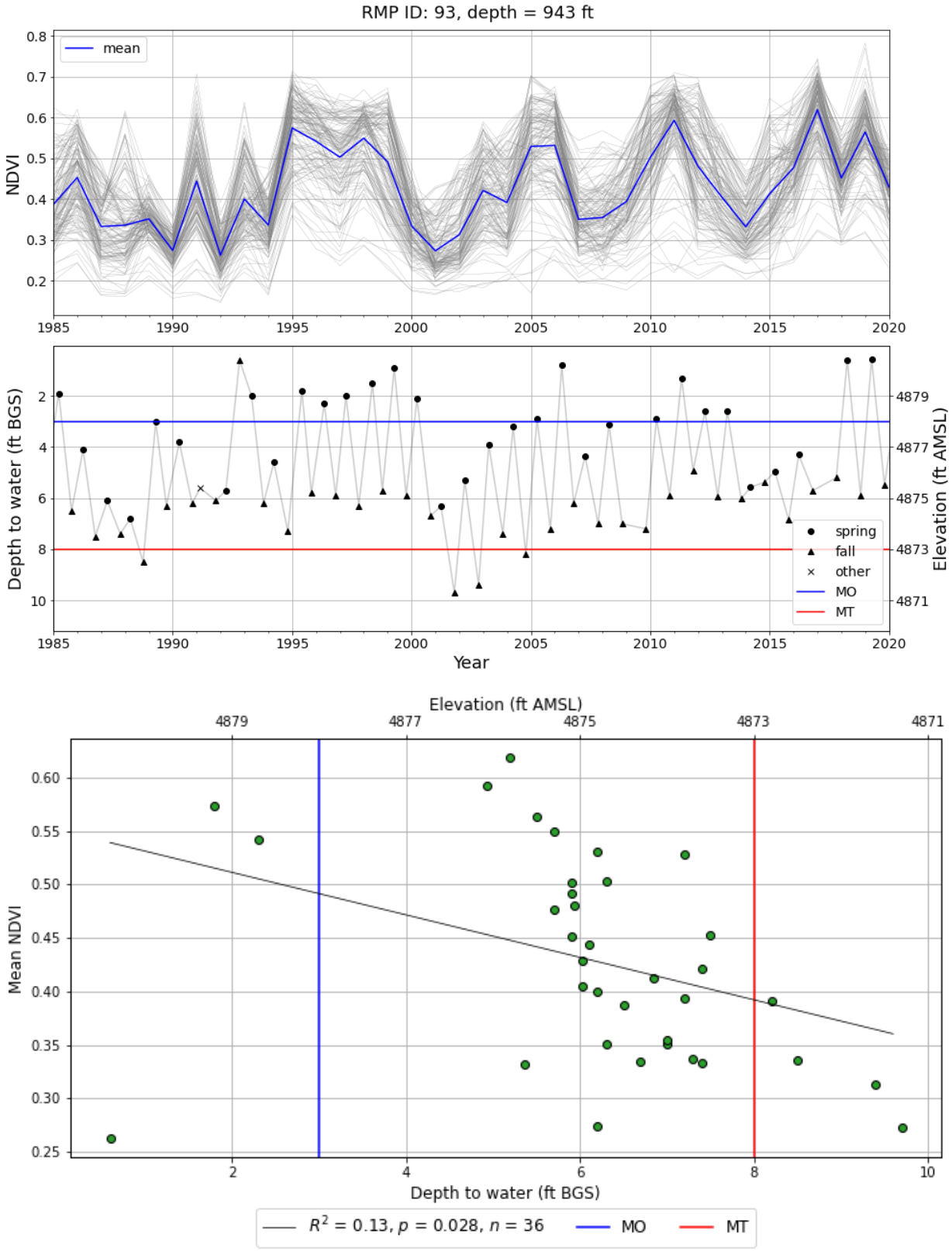

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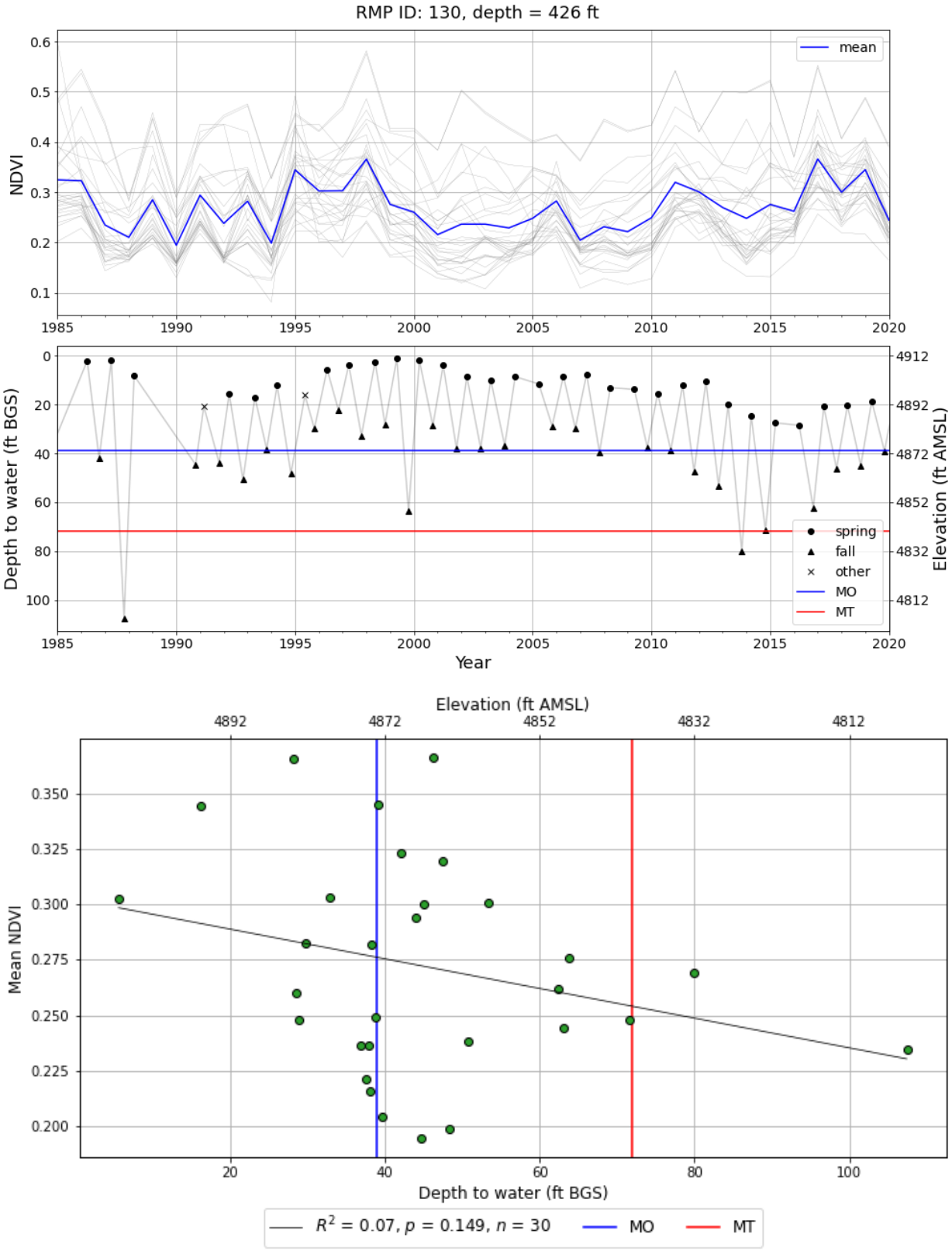

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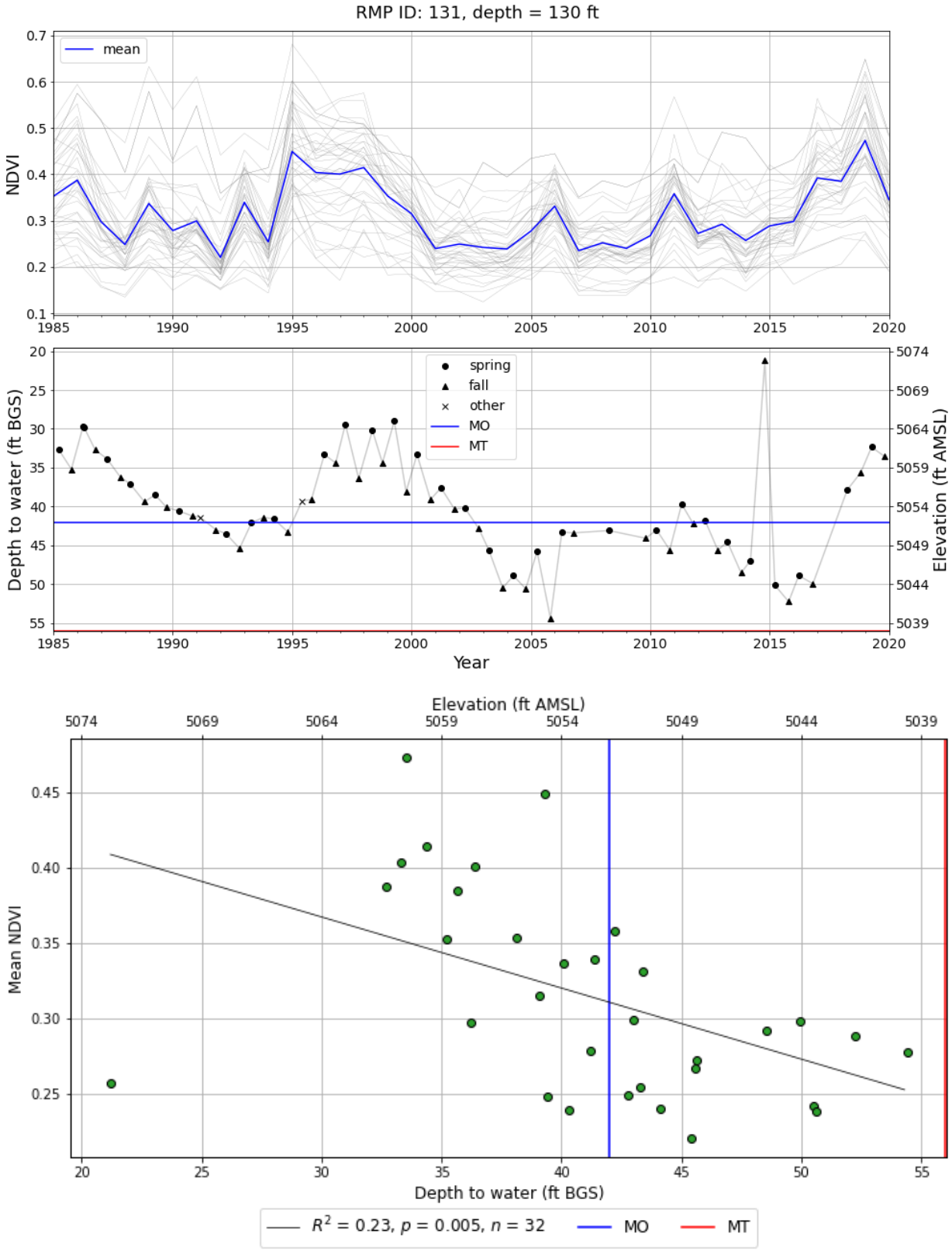

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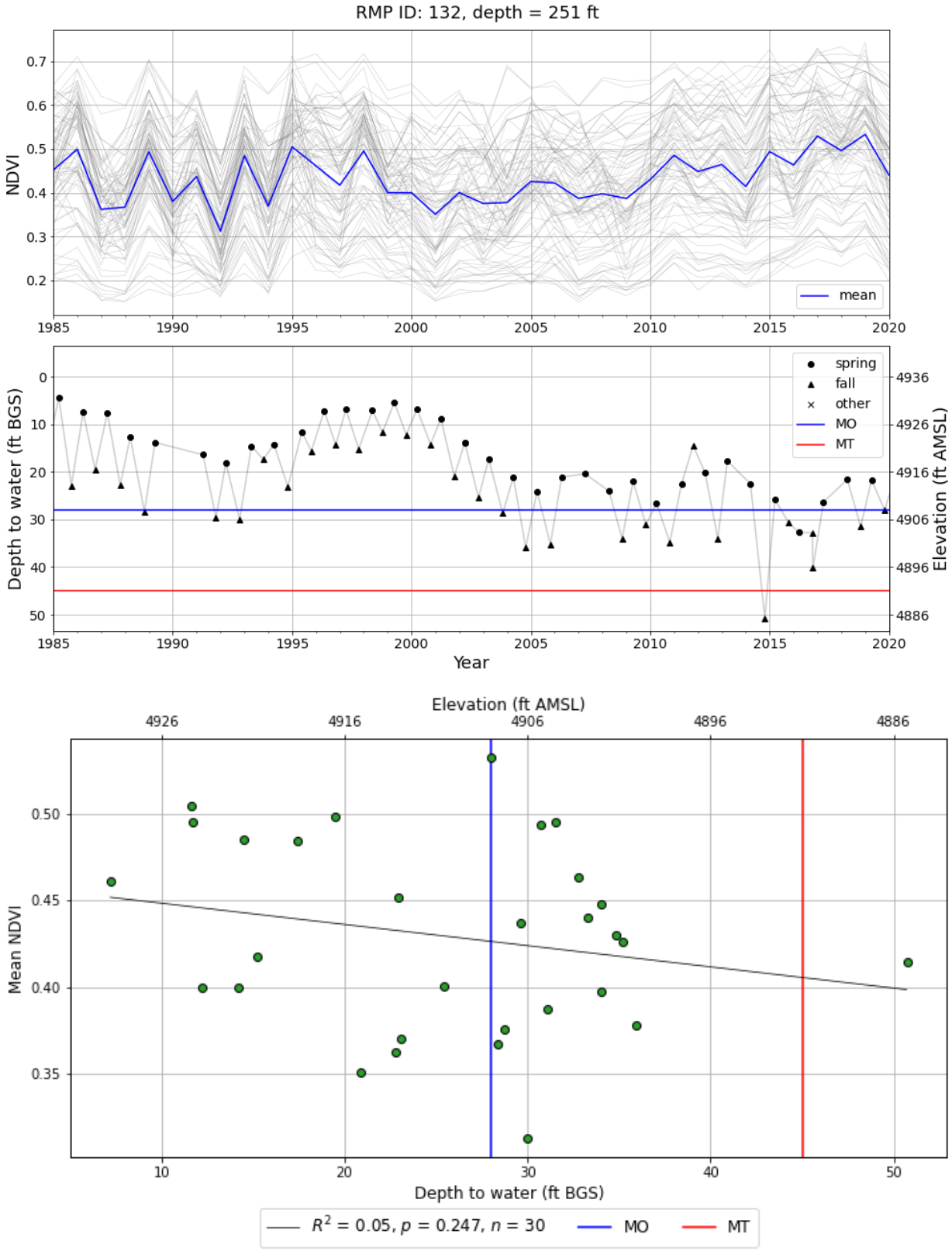

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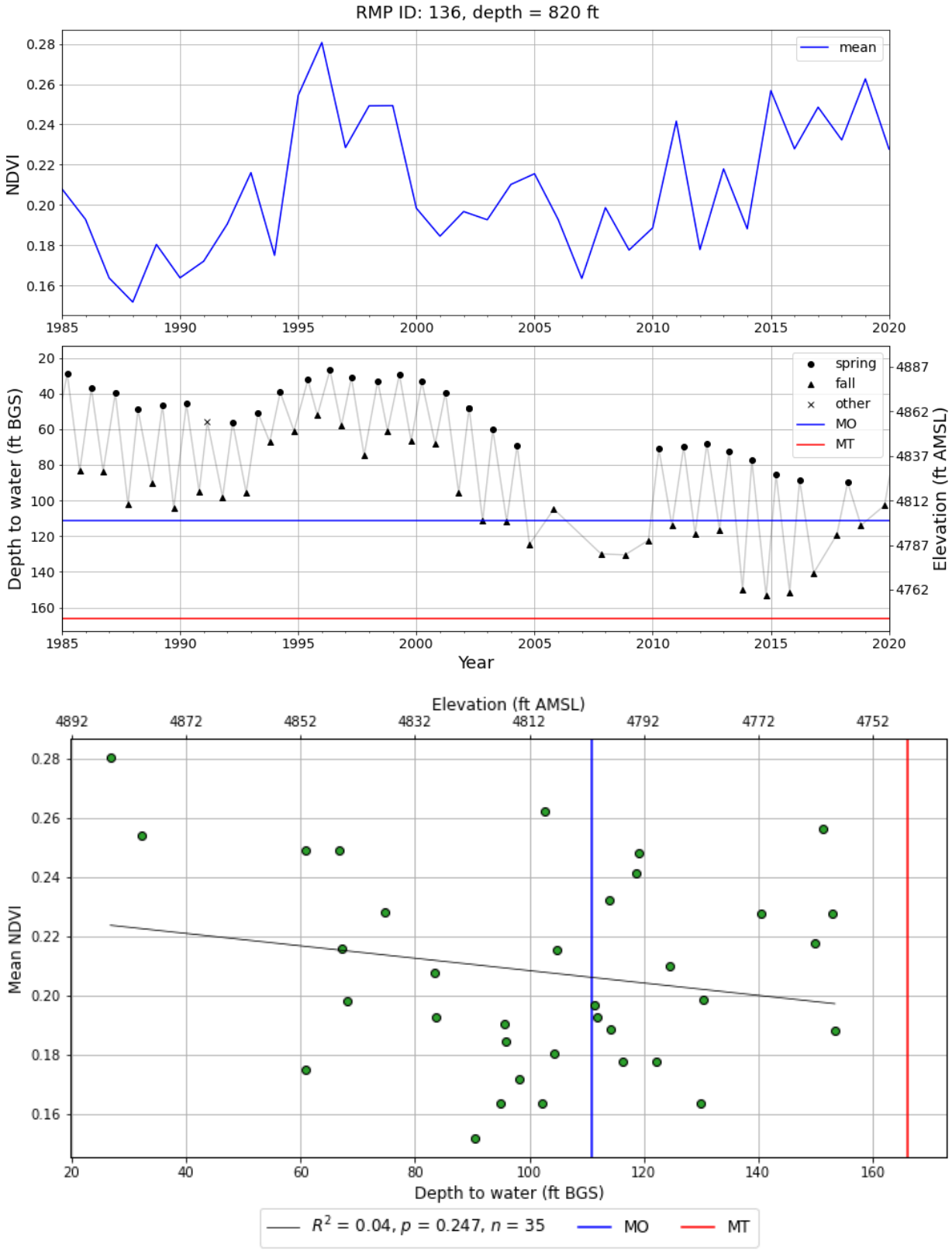

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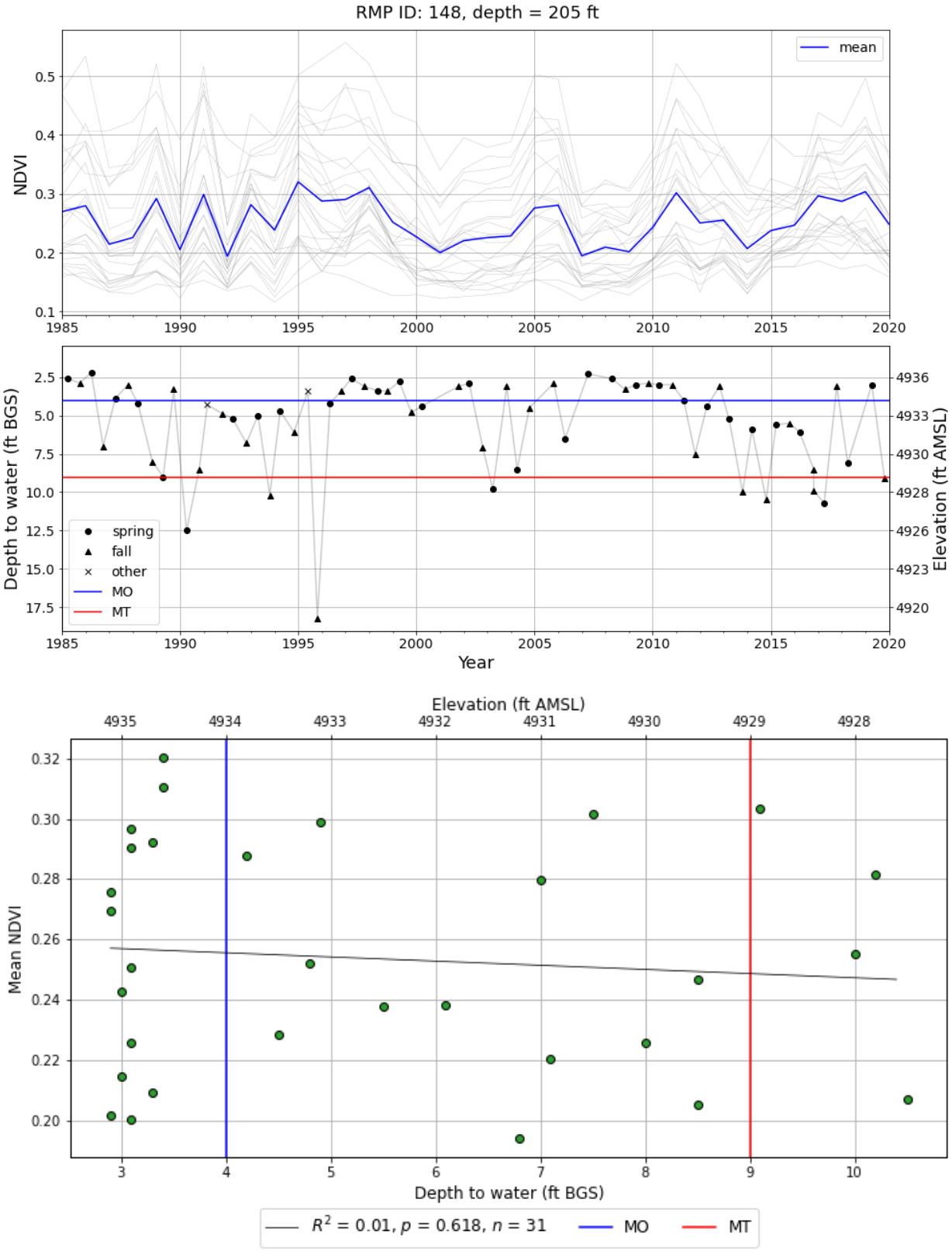

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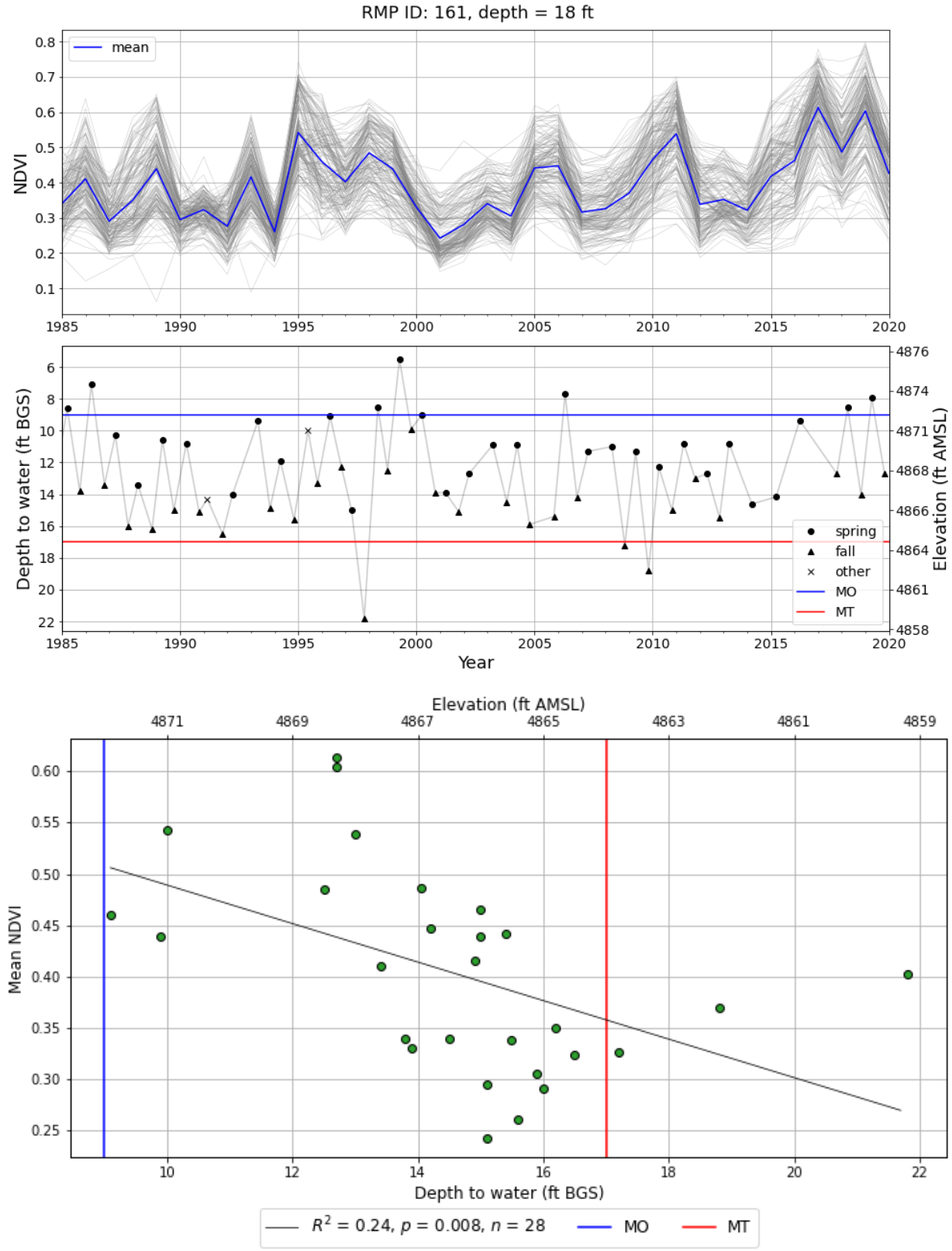

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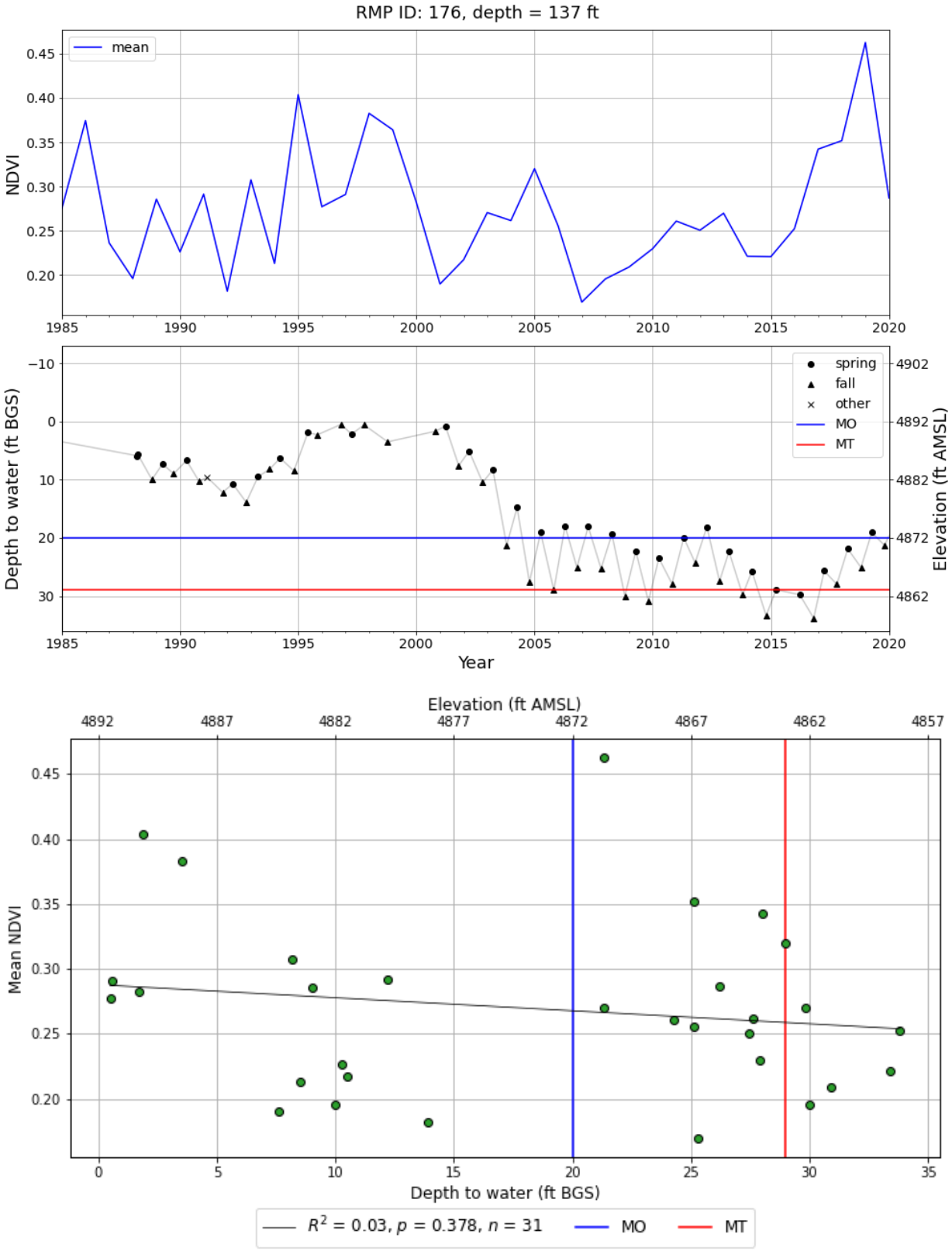

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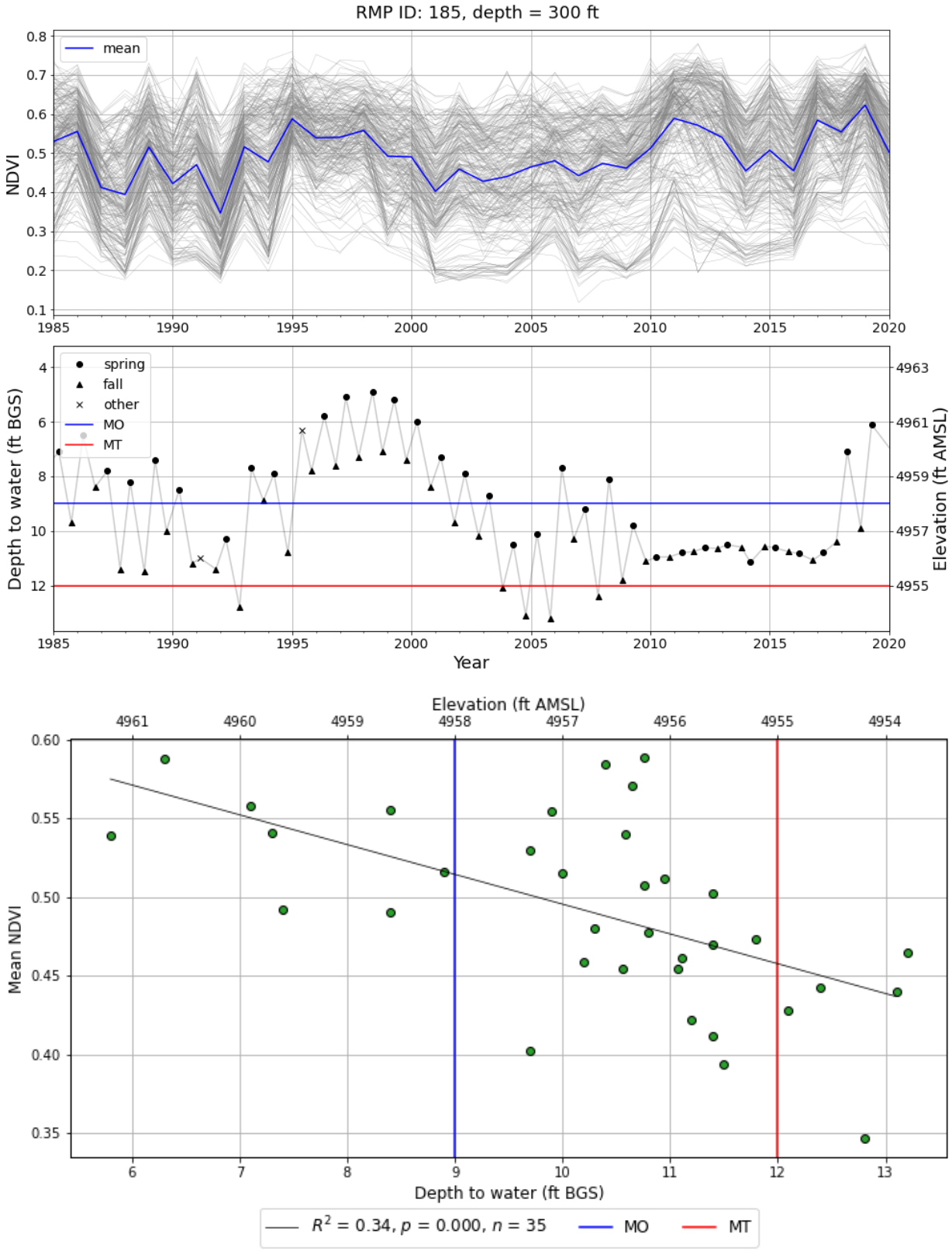

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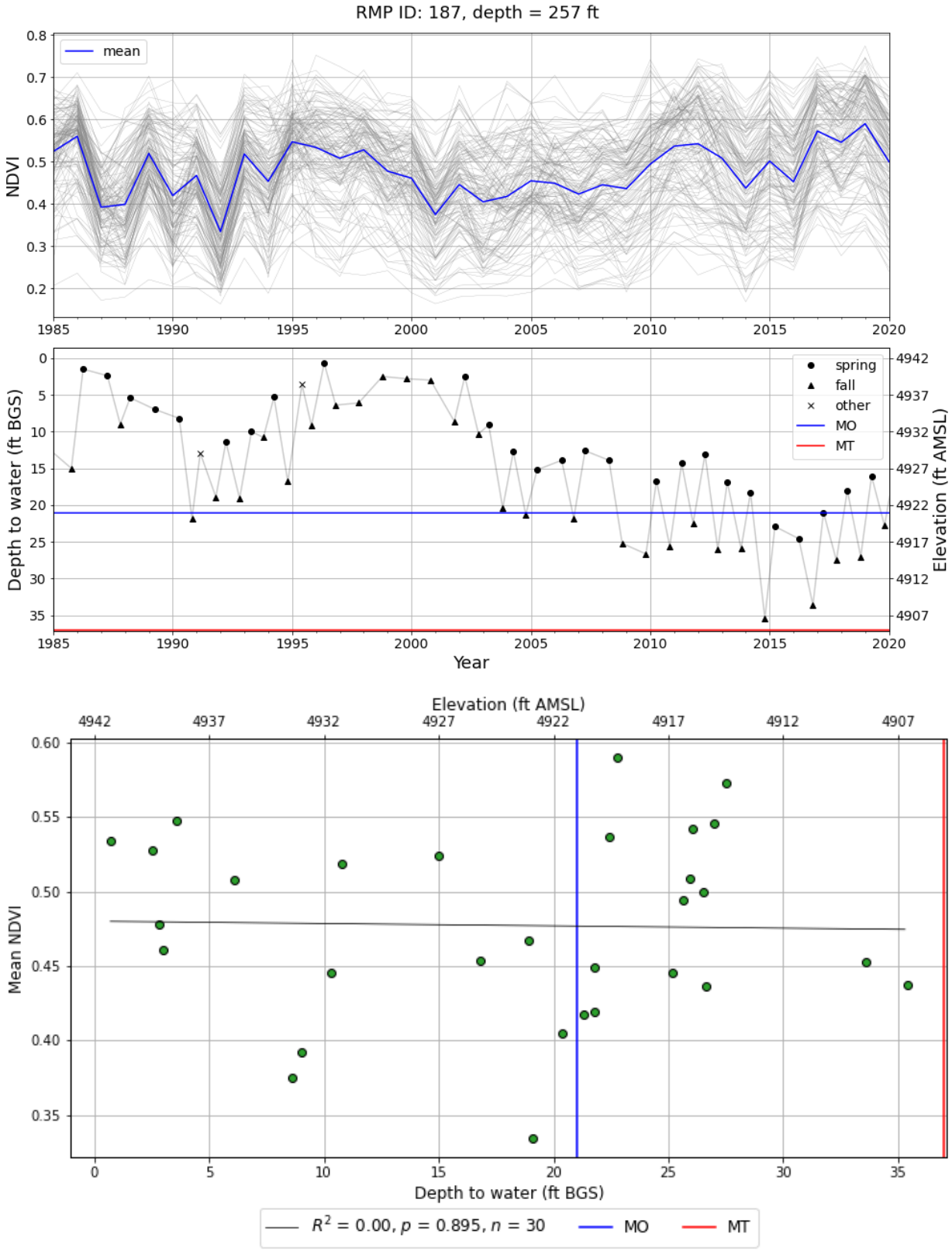

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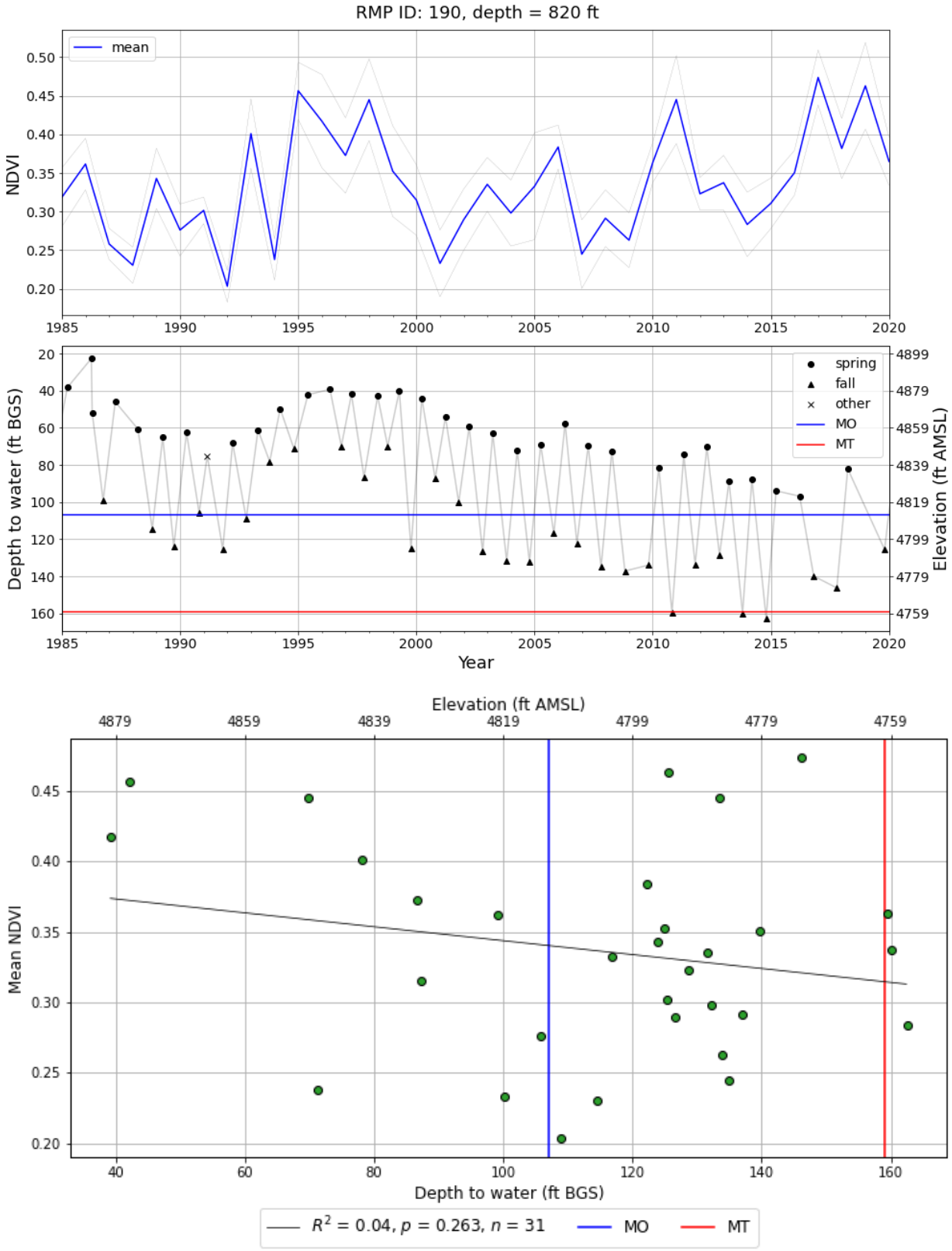

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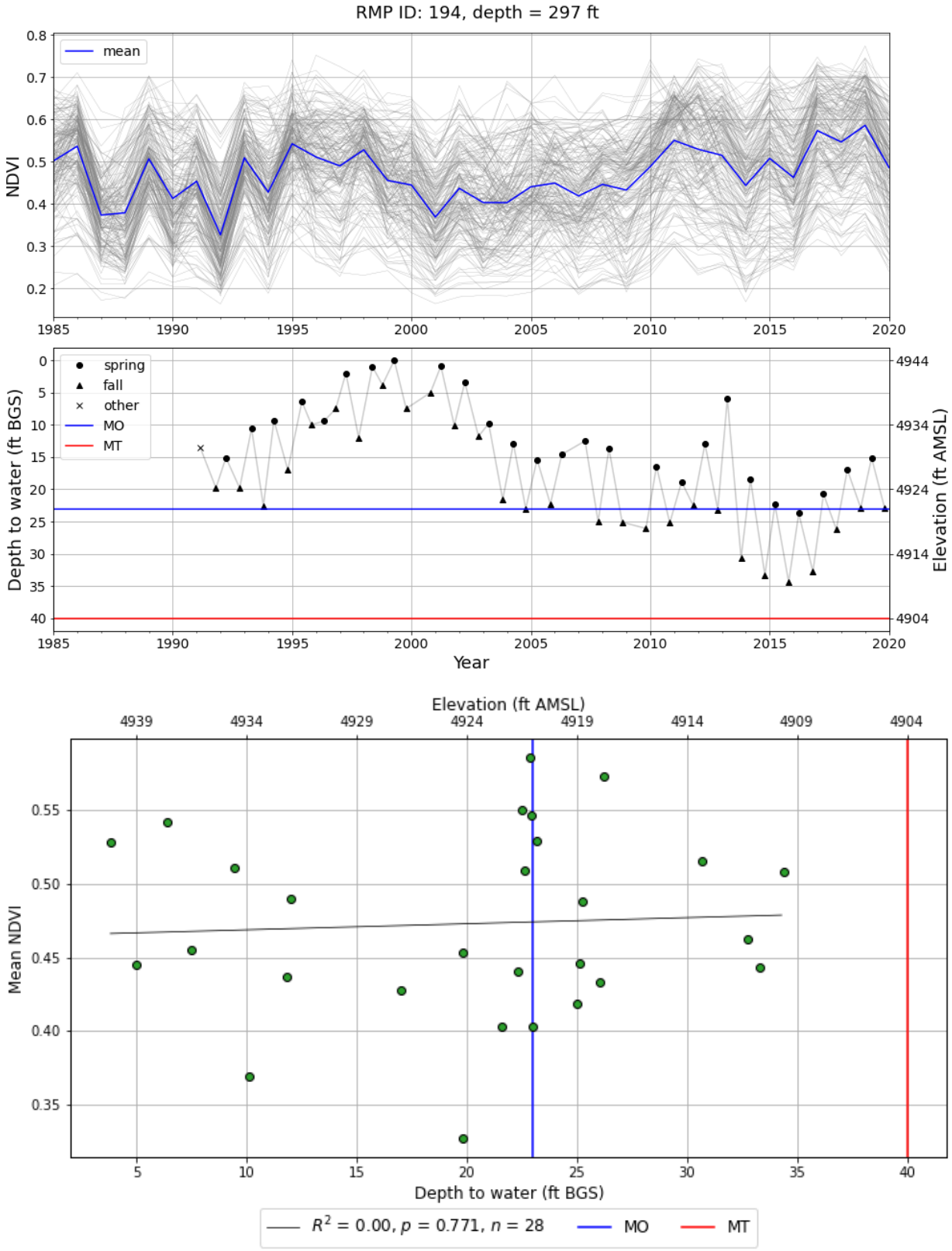

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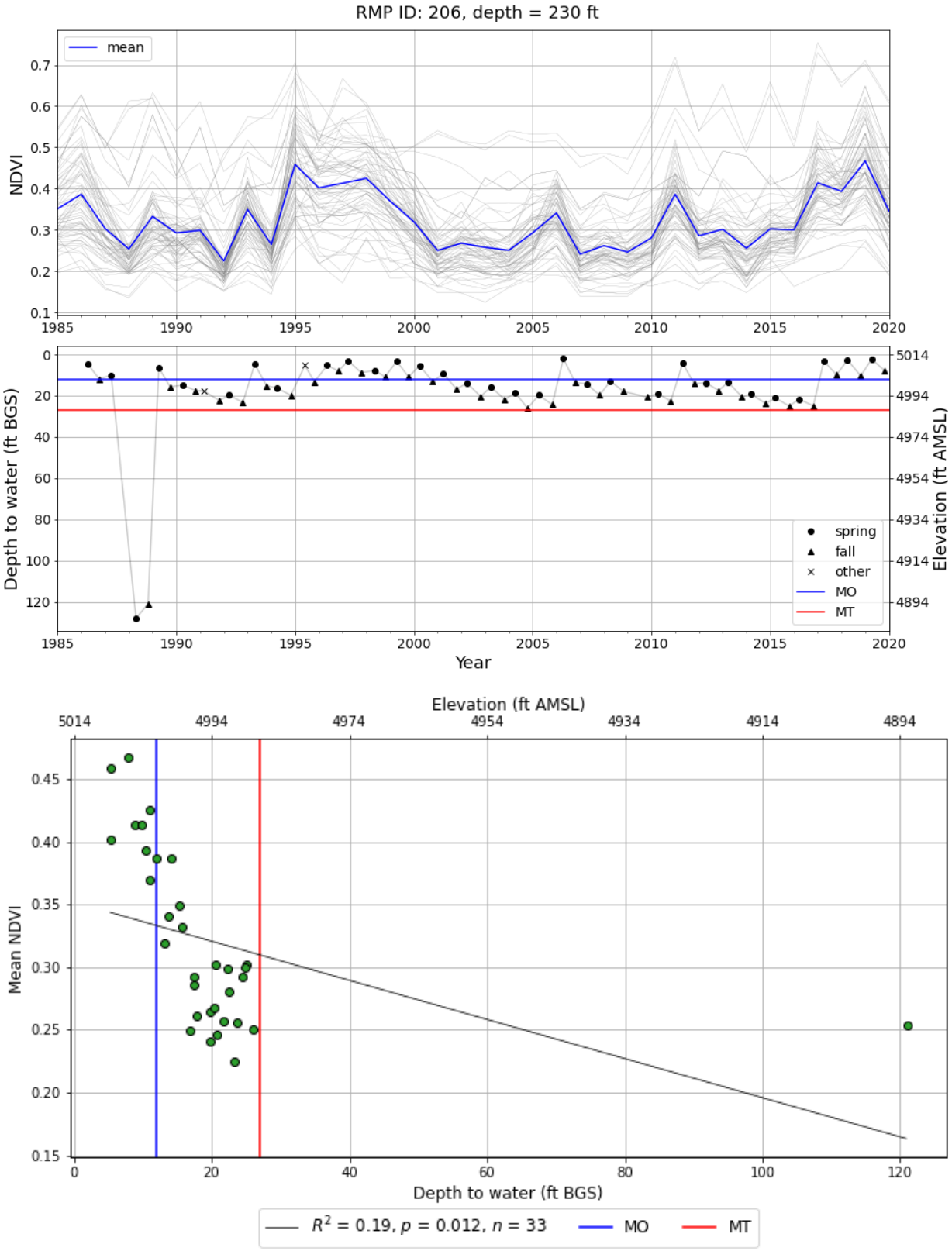

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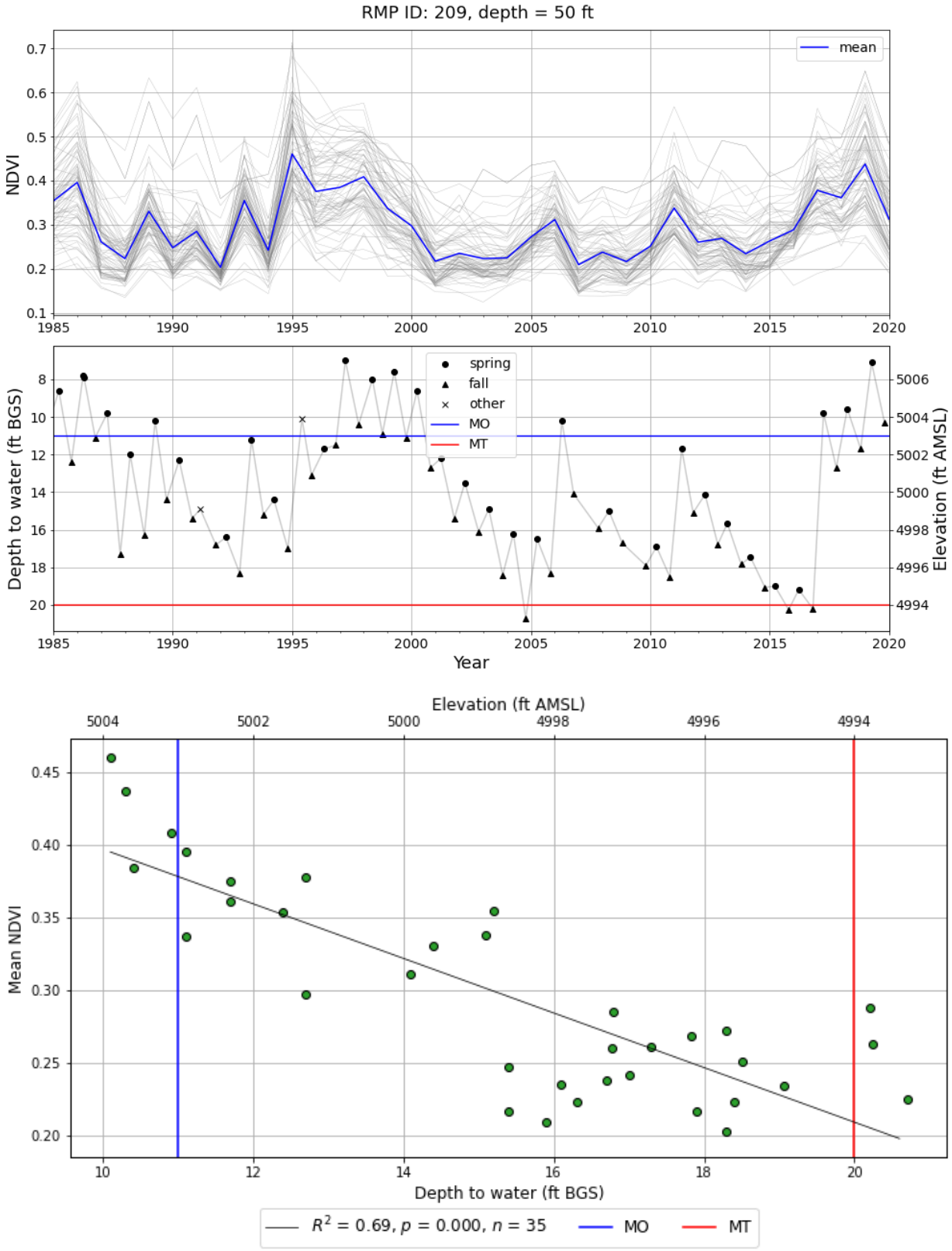

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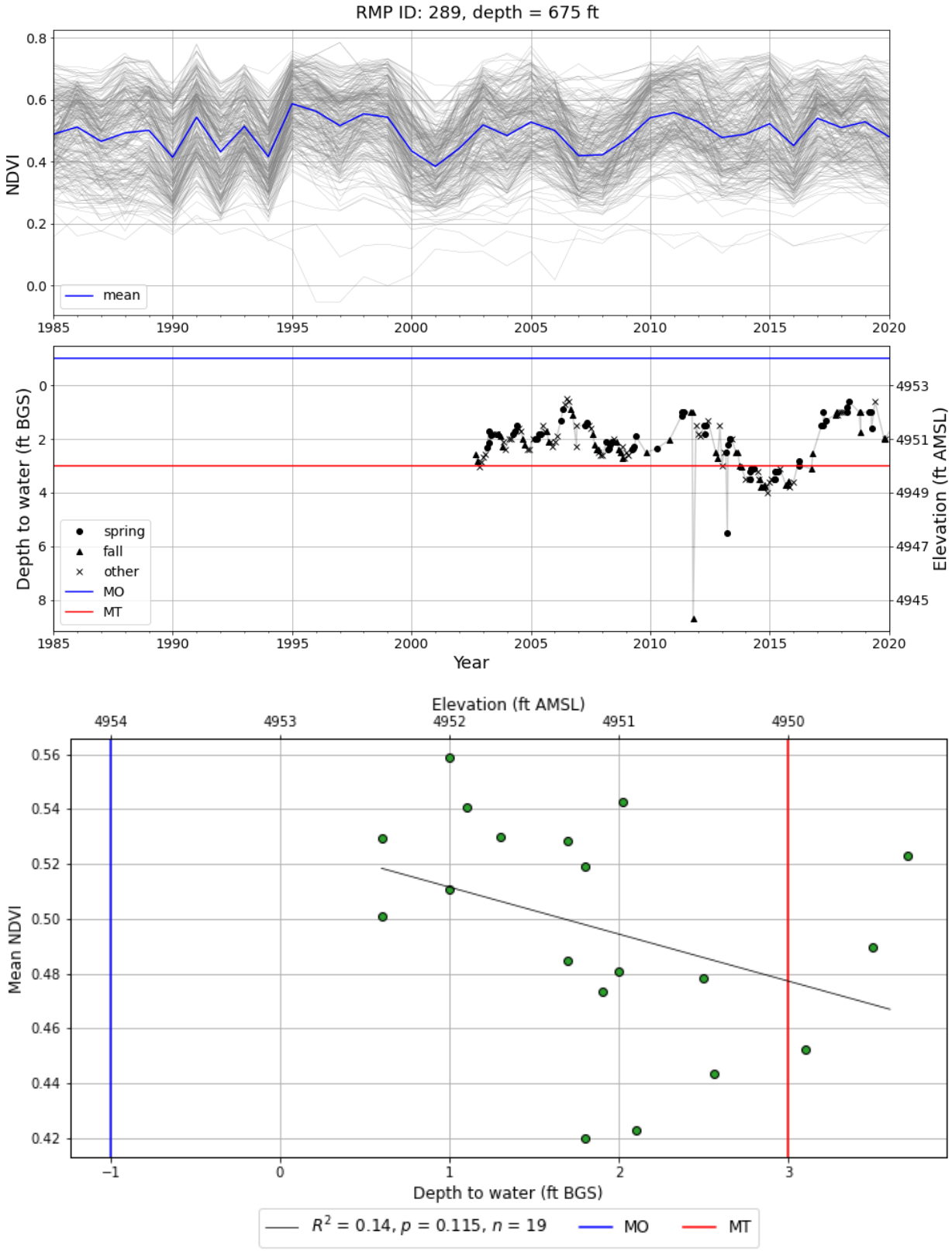

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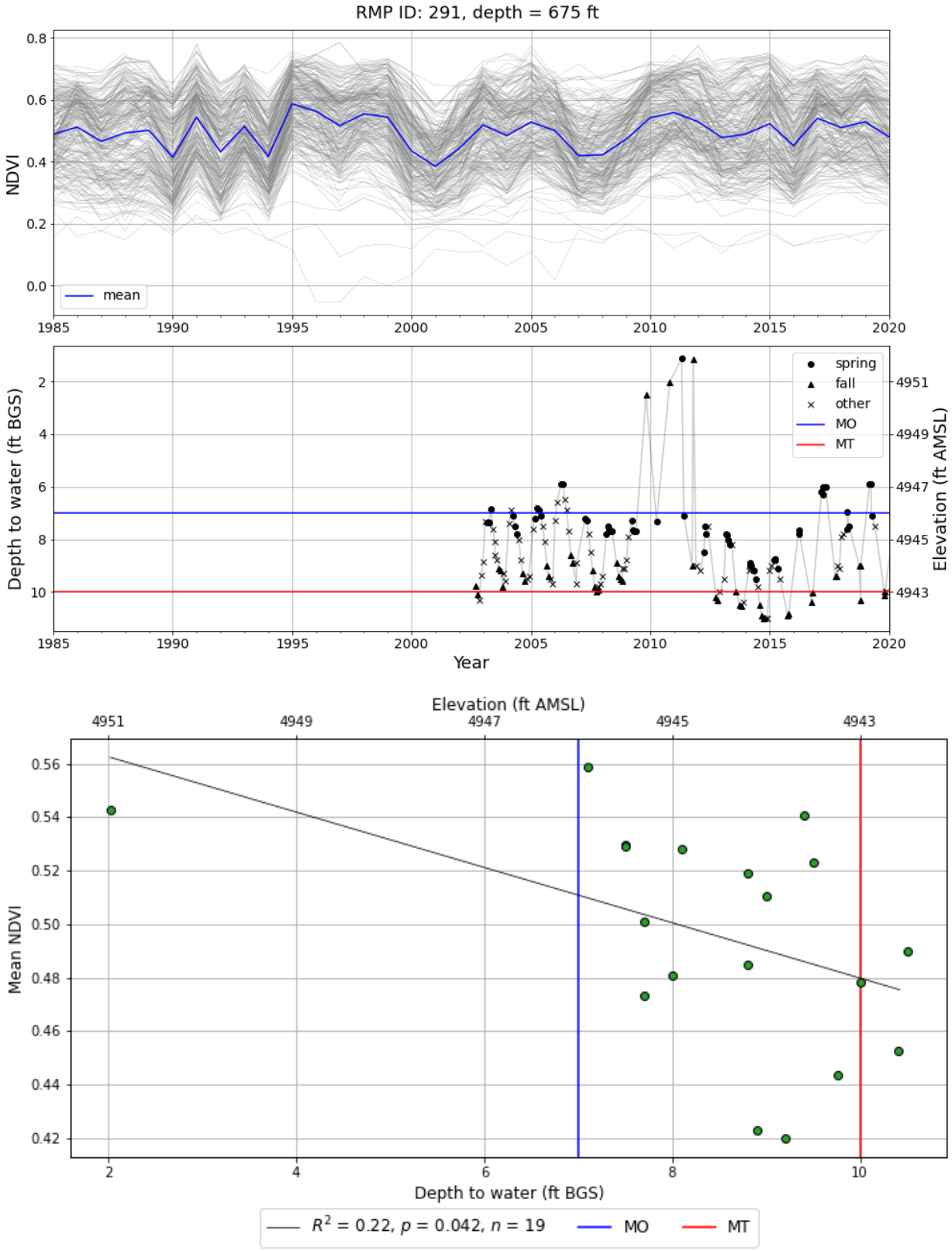

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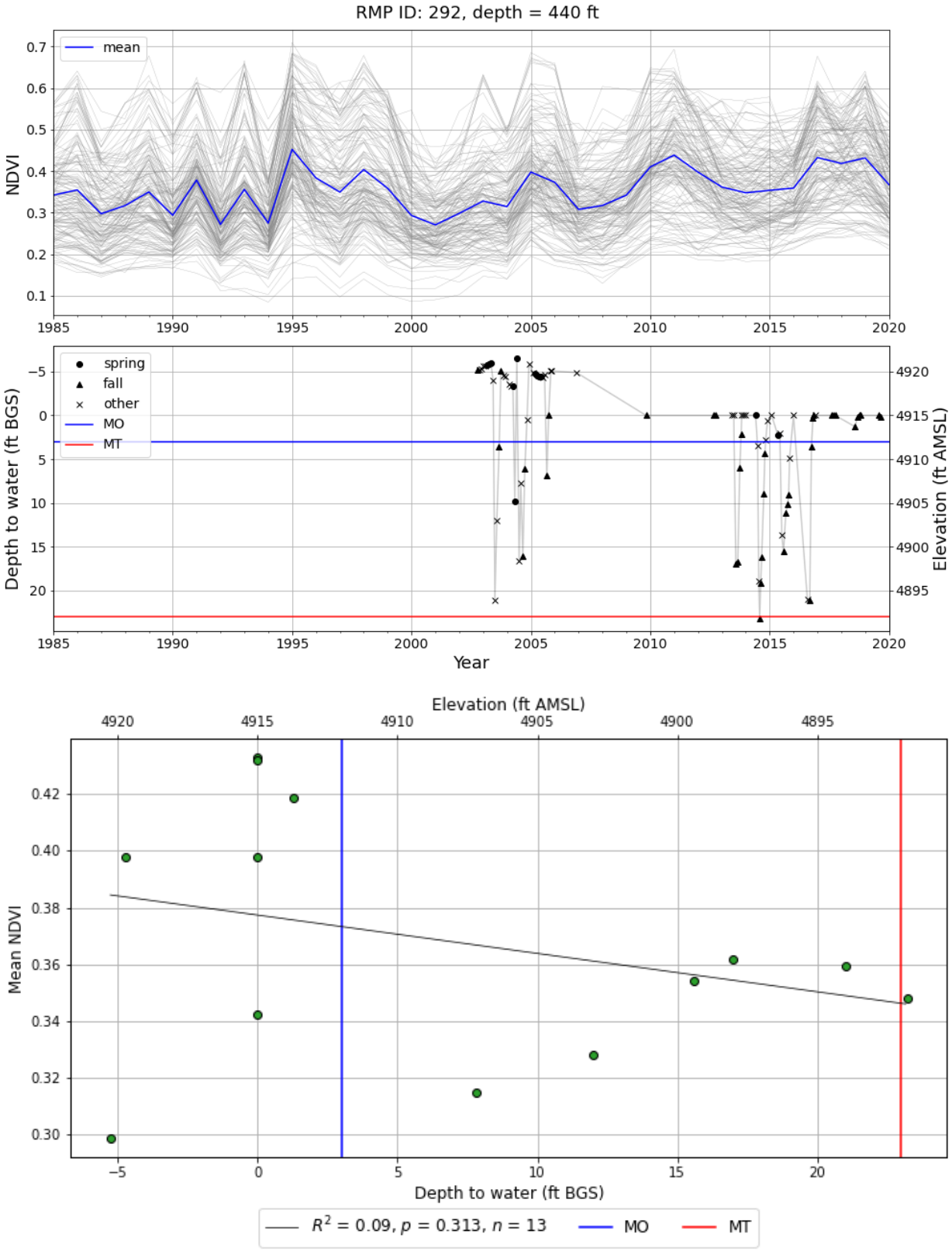

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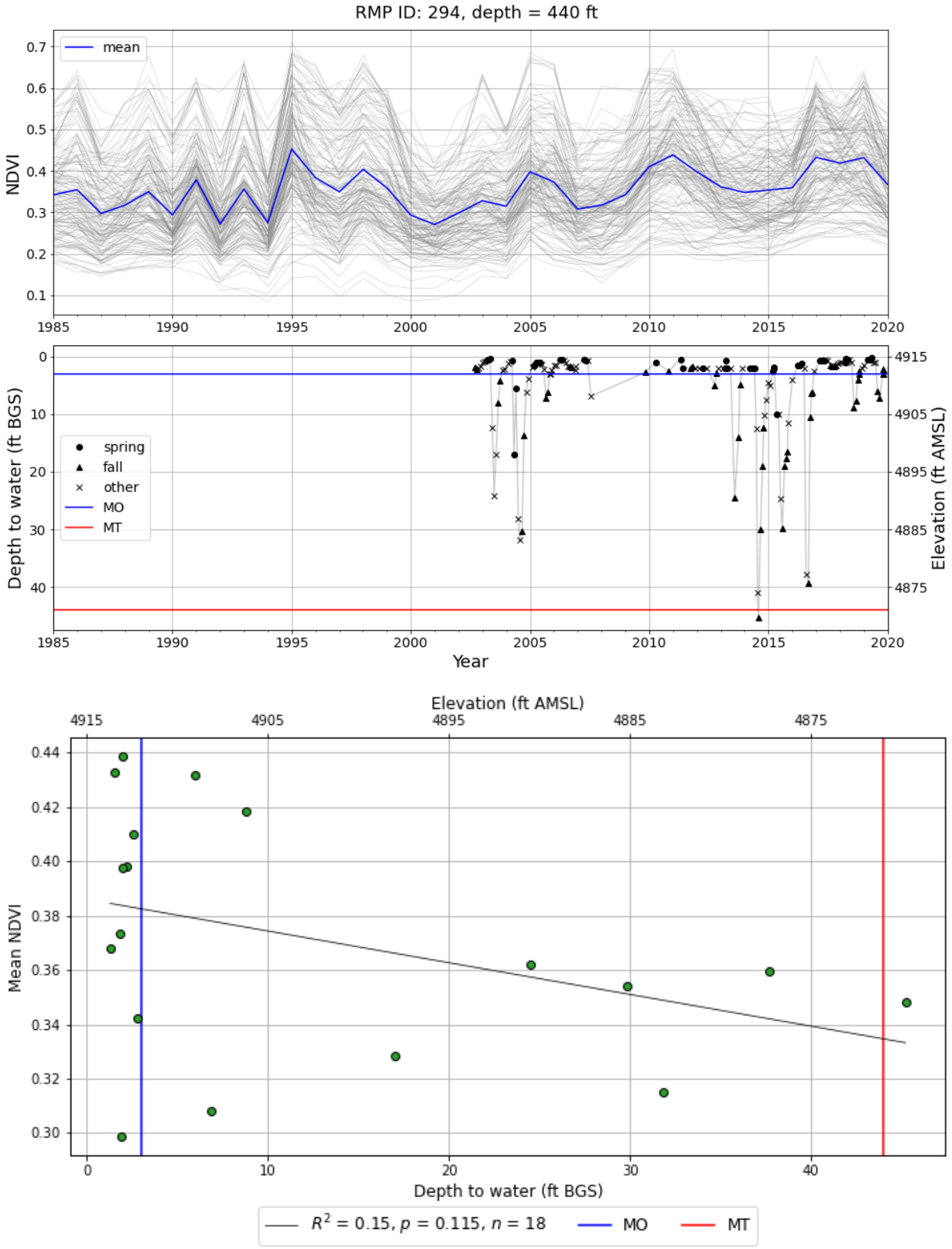

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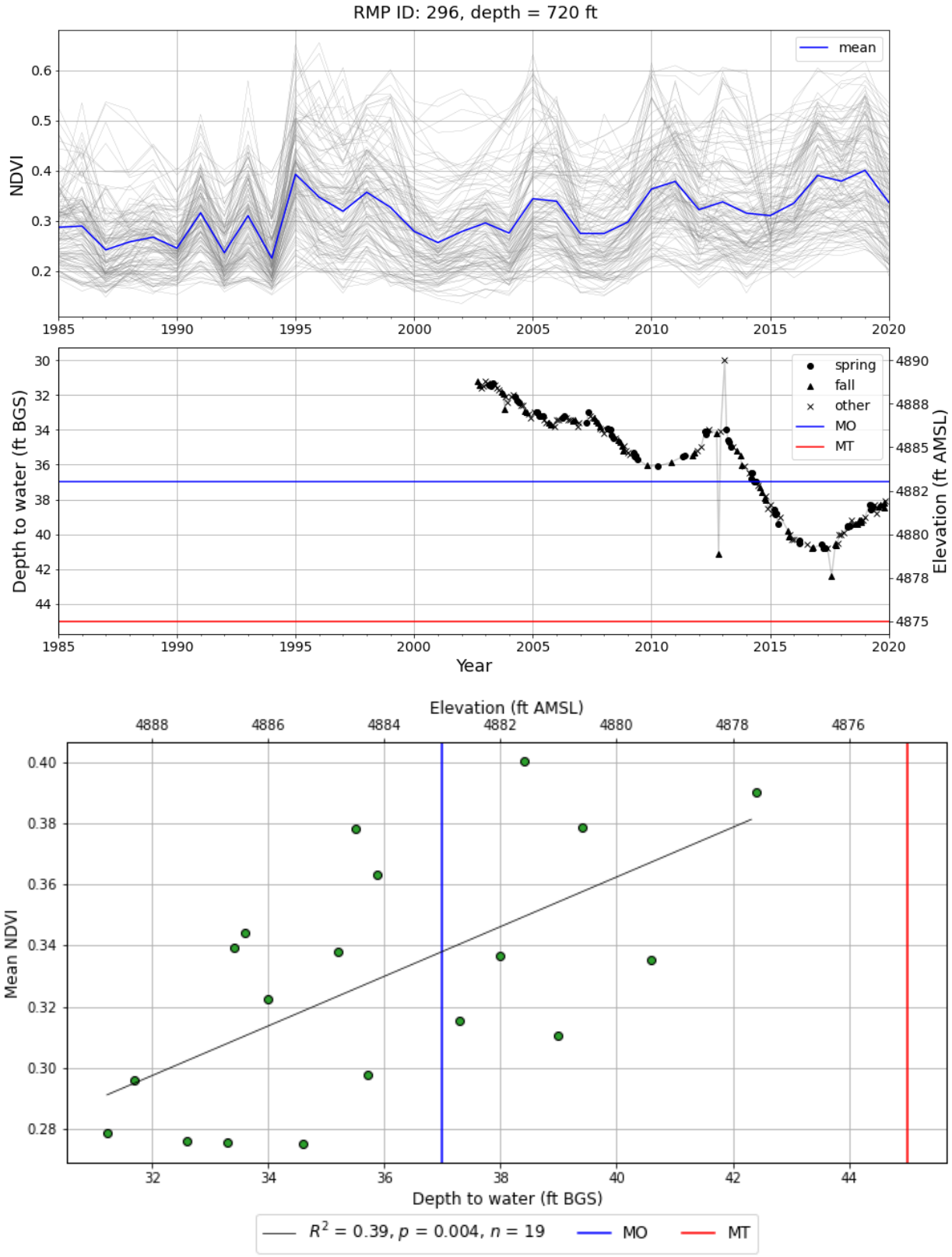

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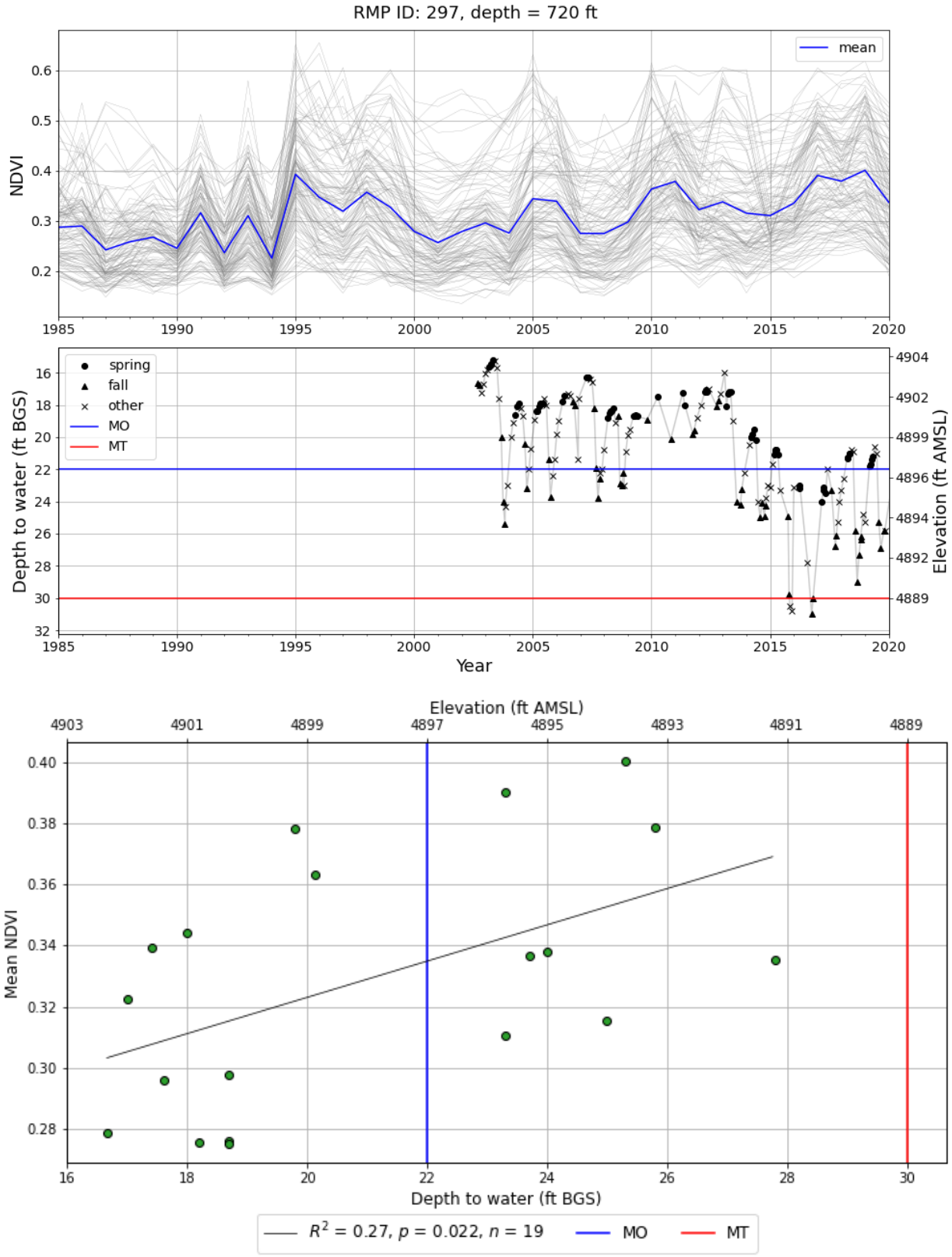

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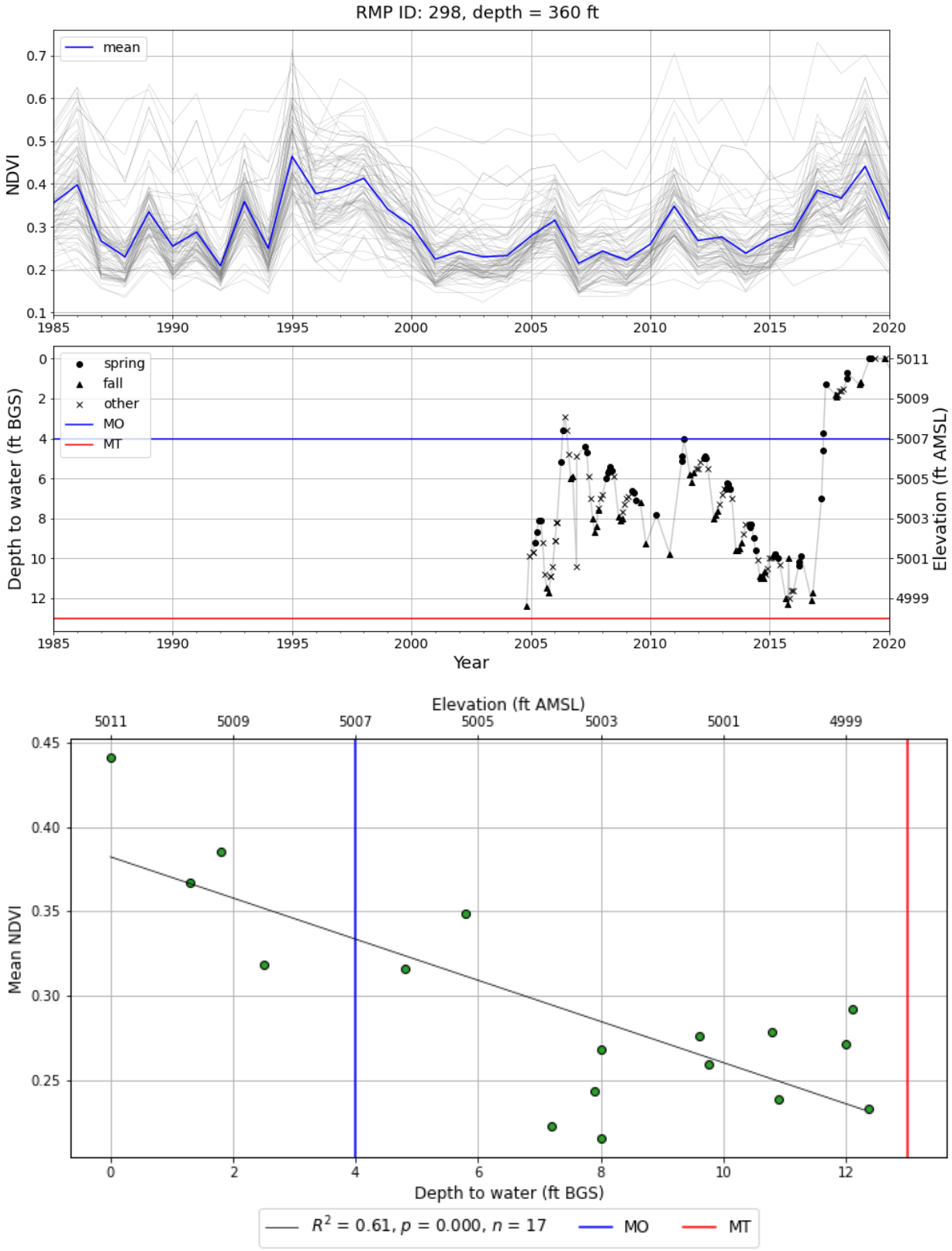

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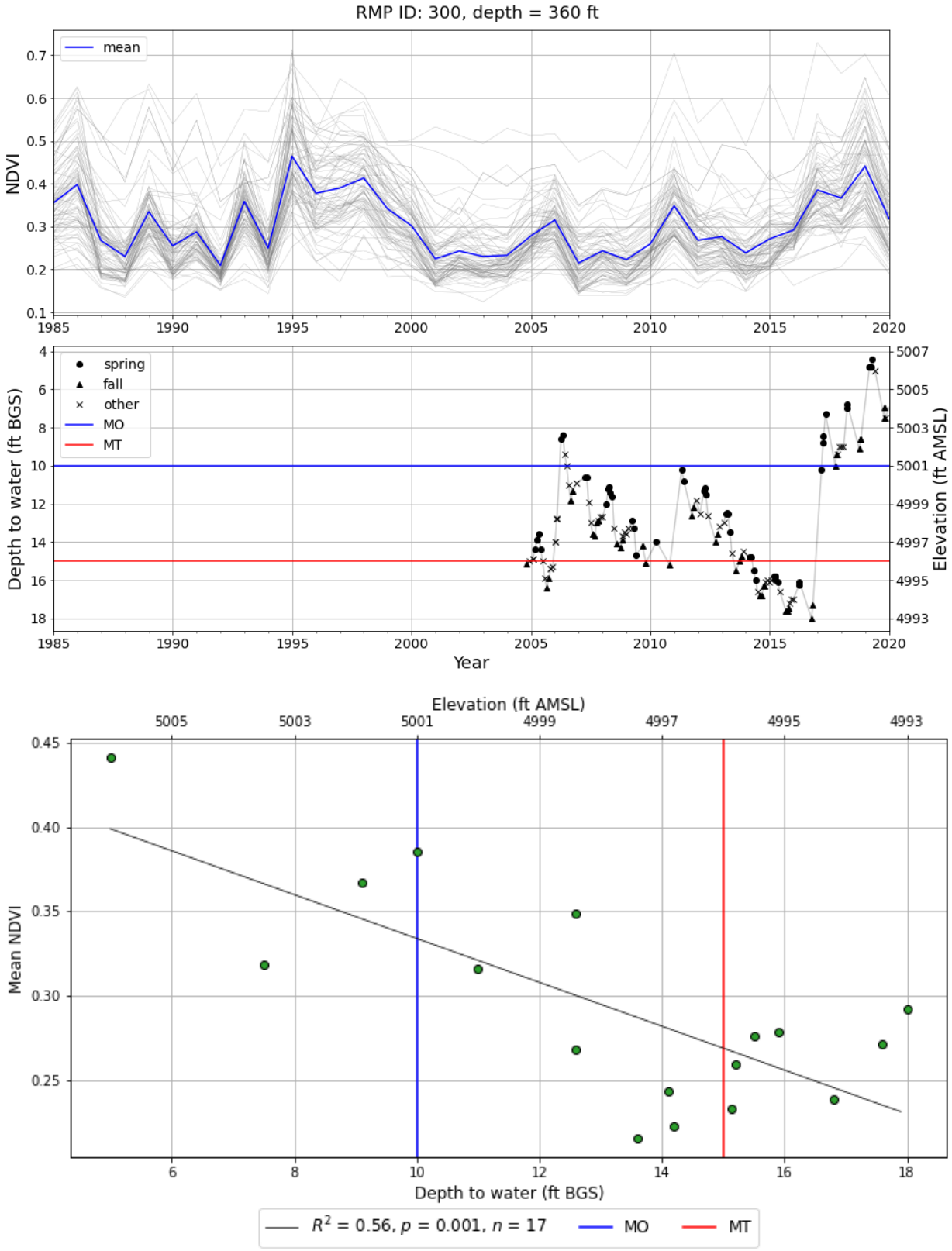

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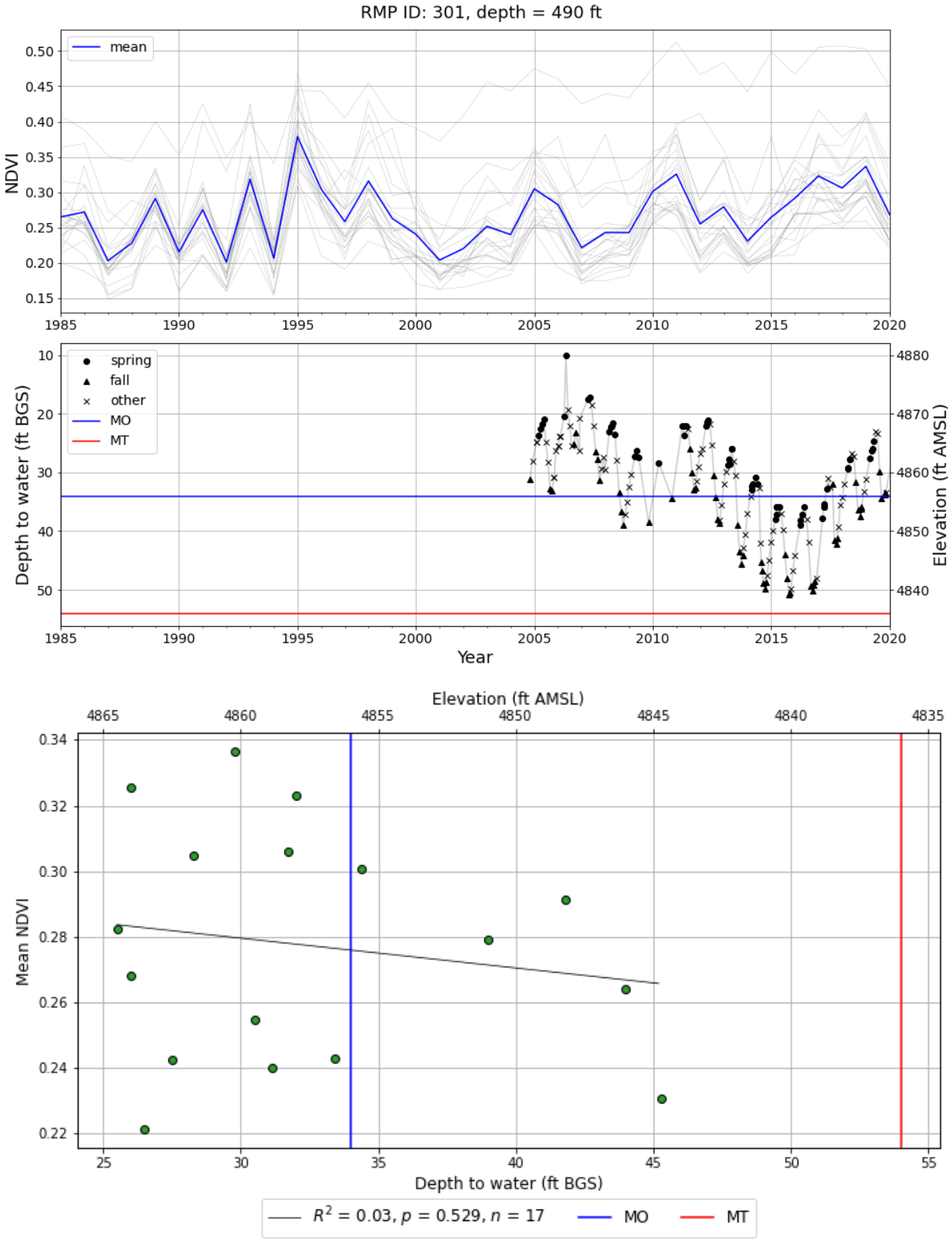

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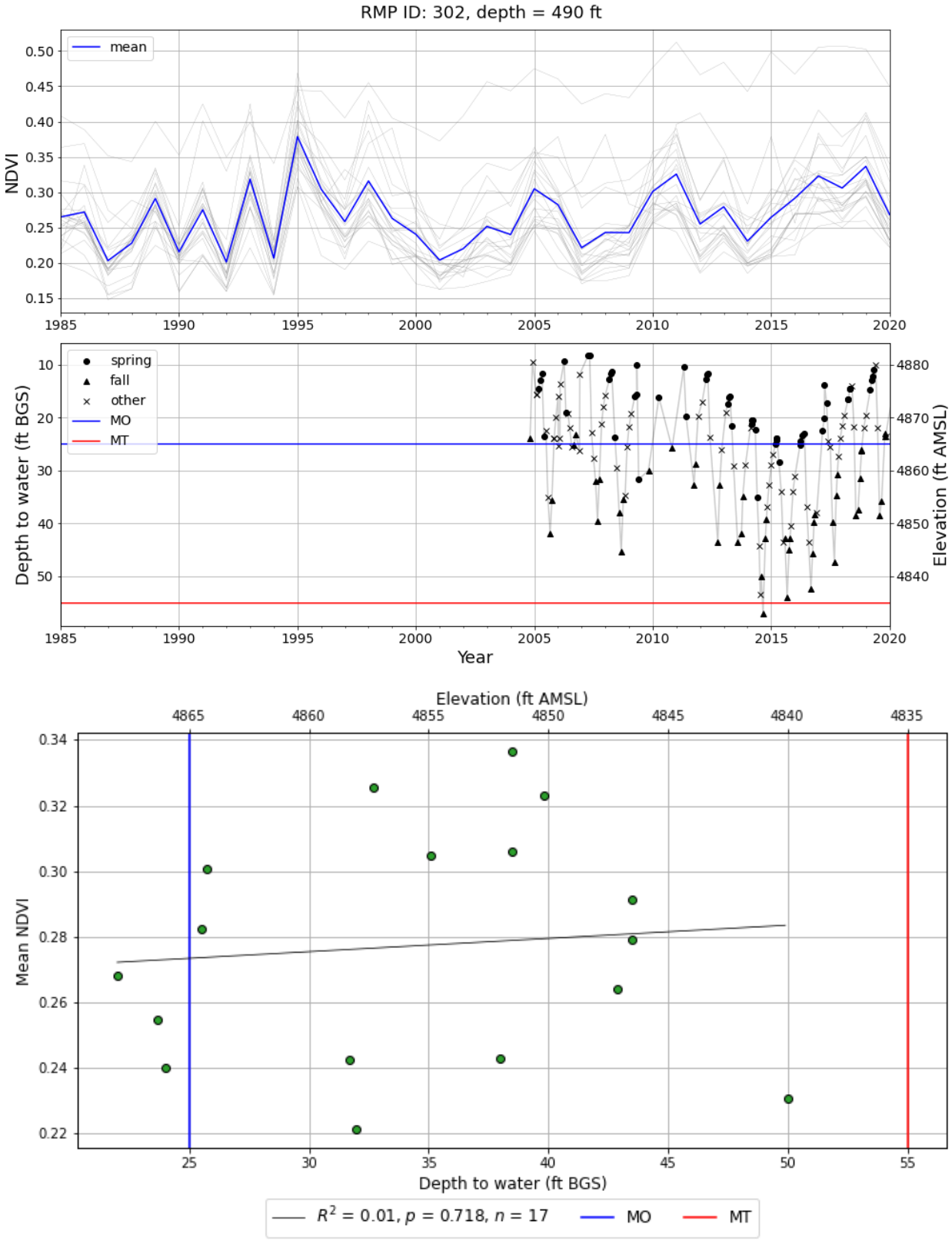

1.3 References

Klausmeyer, K.R., T. Biswas, M.M. Rhode, F. Schuetzenmeister, N. Rindlaub, I. Housman, J.K. Howard. 2019. GDE Pulse: Taking the Pulse of Groundwater Dependent Ecosystems with Satellite Data. The Nature Conservancy, California. Available at: https://gde.codefornature.org/assets/GDE-Pulse-Methods-Report.pdf [Accessed October 2021].